

# Telcordia Blue Book - Manual of Construction Procedures

Special Report

SR-1421

Issue 7, January 2023

***Comments Requested (See Preface)***

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## Blue Book - Manual of Construction Procedures

This document is prepared by Network Infrastructure Solutions (NIS) group, a division of Ericsson Inc. ("Ericsson - NIS").

This document, SR-1421, Issue 7, replaces SR-1421, Issue 6, March 2017.

**Significant additions are shown in this sepia (dark brown) colored text**

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# Table of Contents

|                                                                                              |             |
|----------------------------------------------------------------------------------------------|-------------|
| <b>SPECIAL REPORT NOTICE OF DISCLAIMER .....</b>                                             | <b>III</b>  |
| <b>TABLE OF CONTENTS .....</b>                                                               | <b>V</b>    |
| <b>LIST OF FIGURES .....</b>                                                                 | <b>XVII</b> |
| <b>1 GENERAL .....</b>                                                                       | <b>1-1</b>  |
| 1.1 SCOPE AND PURPOSE .....                                                                  | 1-1         |
| 1.2 SAFETY, DESIGN, RELIABILITY AND RESILIENCY .....                                         | 1-2         |
| 1.3 INTERDEPENDENCE OF COMMUNICATIONS AND POWER UTILITY PLANT .....                          | 1-4         |
| 1.4 COORDINATION BETWEEN CODES, STANDARDS, AND OTHER AGREEMENTS .....                        | 1-8         |
| 1.5 SR-1421 HISTORY .....                                                                    | 1-10        |
| 1.6 BLUE BOOK - ISSUE 7 .....                                                                | 1-11        |
| 1.7 COMPANY TERMINOLOGY .....                                                                | 1-12        |
| 1.8 BLUE BOOK STRUCTURE .....                                                                | 1-13        |
| <b>2 GENERAL SAFETY PRECAUTIONS AND GUIDELINES .....</b>                                     | <b>2-1</b>  |
| 2.1 WORKING IN THE VICINITY OF POWER CONDUCTORS .....                                        | 2-1         |
| 2.1.1 <i>Job Plan or Job Briefing</i> .....                                                  | 2-2         |
| 2.1.2 <i>Made-Safe (or Make-Safe)</i> .....                                                  | 2-3         |
| 2.1.3 <i>Minimum Approach Distances (MADs)</i> .....                                         | 2-8         |
| 2.1.4 <i>Use of Rope</i> .....                                                               | 2-10        |
| 2.2 IDENTIFYING POWER .....                                                                  | 2-11        |
| 2.2.1 <i>Powering of Communications Equipment and Smart Grid Devices</i> .....               | 2-13        |
| 2.2.2 <i>Electric Safety of Communications Circuits - Arc Flash and Electric Shock</i> ..... | 2-16        |
| 2.3 USING TRUCK-MOUNTED EQUIPMENT NEAR POWER .....                                           | 2-23        |
| 2.4 PLACING OR REMOVING POLES NEAR POWER .....                                               | 2-24        |
| 2.5 PLACING OR REMOVING SUSPENSION STRAND AND CABLE NEAR POWER .....                         | 2-26        |
| 2.6 VISUAL POLE INSPECTION .....                                                             | 2-27        |
| 2.7 CONDITIONS REQUIRING NO TESTING OR SUPPLEMENTAL SUPPORT .....                            | 2-28        |
| 2.8 BURIED PLANT PRECAUTIONS .....                                                           | 2-29        |
| 2.9 DEPTH OF BURIED PLANT .....                                                              | 2-31        |
| 2.10 SEPARATION FROM GAS AND OTHER FUEL LINES .....                                          | 2-33        |
| 2.10.1 <i>Steam Lines</i> .....                                                              | 2-33        |
| 2.11 SAFETY CONSIDERATIONS .....                                                             | 2-34        |
| 2.12 MANHOLES .....                                                                          | 2-36        |
| 2.13 OPTICAL FIBERS .....                                                                    | 2-36        |
| 2.14 WIRELESS FACILITIES .....                                                               | 2-37        |
| 2.15 INSPECTION CHECKLIST .....                                                              | 2-38        |
| 2.15.1 <i>Inspection and Test – NESC Rules 214 and 313</i> .....                             | 2-40        |
| 2.16 MAKE-READY SURVEY CHECKLIST .....                                                       | 2-41        |
| 2.16.1 <i>Internet and NESC Resources</i> .....                                              | 2-41        |
| 2.17 PERSONAL PROTECTION EQUIPMENT (PPE) .....                                               | 2-43        |
| <b>3 CLEARANCES .....</b>                                                                    | <b>3-1</b>  |
| 3.1 GENERAL .....                                                                            | 3-1         |
| 3.2 CLEARANCES BETWEEN COMMUNICATIONS FACILITIES .....                                       | 3-2         |
| 3.2.1 <i>Hierarchy on Pole</i> .....                                                         | 3-5         |
| 3.3 CLEARANCE BETWEEN POWER AND COMMUNICATIONS FACILITIES .....                              | 3-6         |

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|          |                                                                                 |             |
|----------|---------------------------------------------------------------------------------|-------------|
| 3.3.1    | <i>Congestion on Poles</i> .....                                                | 3-6         |
| 3.3.2    | <i>Clearances Between Power and Communications Facilities</i> .....             | 3-8         |
| 3.3.3    | <i>Supply Equipment in Communications Space</i> .....                           | 3-13        |
| 3.4      | CLEARANCE BETWEEN POWER AND COMMUNICATIONS CABLES ON DIFFERENT POLES.....       | 3-14        |
| 3.5      | CLEARANCE BETWEEN POWER AND COMMUNICATIONS CONDUCTORS ALONG SPAN.....           | 3-15        |
| 3.6      | CLEARANCES ABOVE ROADWAYS, RAILS, AND OTHER STRUCTURES .....                    | 3-19        |
| 3.6.1    | <i>Clearance Example</i> .....                                                  | 3-21        |
| 3.7      | COMMUNICATIONS ANTENNAS .....                                                   | 3-23        |
| 3.7.1    | <i>Basic Clearances</i> .....                                                   | 3-24        |
| 3.7.2    | <i>Placement Concerns for Antenna and Associated Equipment</i> .....            | 3-25        |
| 3.7.3    | <i>Clearances for Antenna Structures, Cables, and Associated Closures</i> ..... | 3-27        |
| 3.7.4    | <i>Radiation Emissions</i> .....                                                | 3-27        |
| 3.8      | CLEARANCE OF SUPPORTING STRUCTURES (POLES) FROM OTHER OBJECTS.....              | 3-27        |
| 3.8.1    | <i>Pole Placement Along Roadways</i> .....                                      | 3-28        |
| 3.8.2    | <i>Reflector Markers and Strips</i> .....                                       | 3-30        |
| 3.9      | CLIMBING SPACE.....                                                             | 3-31        |
| 3.10     | SERVICE DROP CLEARANCES AND SEPARATIONS.....                                    | 3-32        |
| 3.10.1   | <i>Service Masts</i> .....                                                      | 3-34        |
| 3.10.2   | <i>Vegetation Management</i> .....                                              | 3-36        |
| 3.11     | CURRENT TRENDS CONCERNING CLEARANCES AND SEPARATIONS .....                      | 3-37        |
| 3.12     | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO CLEARANCES.....                 | 3-39        |
| <b>4</b> | <b>STRAND - DESCRIPTION AND STRINGING TENSION .....</b>                         | <b>4-1</b>  |
| 4.1      | GENERAL .....                                                                   | 4-1         |
| 4.2      | STRAND DESCRIPTION .....                                                        | 4-2         |
| 4.3      | STRINGING TENSION .....                                                         | 4-4         |
| 4.4      | METHODS OF OBTAINING STRINGING TENSION .....                                    | 4-5         |
| 4.5      | TENSIONING AND SAGGING OF CABLE STRAND.....                                     | 4-6         |
| 4.6      | STRAND CHOICES .....                                                            | 4-7         |
| 4.6.1    | <i>Suspension Strand Choices for Optical Fiber</i> .....                        | 4-7         |
| 4.6.2    | <i>Coastal Zones</i> .....                                                      | 4-8         |
| 4.6.3    | <i>Strand Size Considerations - 6 M Versus 6.6 M</i> .....                      | 4-9         |
| 4.7      | OVERLASHED CABLES AND STRAND-MOUNTED EQUIPMENT CONSIDERATIONS.....              | 4-12        |
| 4.8      | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO CLEARANCES.....                 | 4-14        |
| <b>5</b> | <b>POLE LINE HARDWARE - DESCRIPTION AND USE.....</b>                            | <b>5-15</b> |
| 5.1      | GENERAL .....                                                                   | 5-15        |
| 5.1.1    | <i>Hardware Functional Requirements</i> .....                                   | 5-15        |
| 5.1.2    | <i>Hardware Categories</i> .....                                                | 5-16        |
| 5.2      | SUSPENSION CLAMPS .....                                                         | 5-17        |
| 5.3      | SUSPENSION BOLTS .....                                                          | 5-19        |
| 5.4      | SUSPENSION SCREWS .....                                                         | 5-22        |
| 5.5      | REINFORCING AND SUPPORT STRAPS.....                                             | 5-23        |
| 5.6      | REINFORCING LINKS .....                                                         | 5-26        |
| 5.7      | TABLE OF HARDWARE FOR ATTACHING SUSPENSION STRAND.....                          | 5-29        |
| 5.8      | GUY HOOKS .....                                                                 | 5-30        |
| 5.9      | THIMBLE EYE BOLTS.....                                                          | 5-33        |
| 5.10     | GUY STRAPS.....                                                                 | 5-36        |
| 5.11     | GUY CLAMPS.....                                                                 | 5-37        |
| 5.12     | GUY GRIPS ("B" STRAND GRIPS).....                                               | 5-39        |

|          |                                                                     |            |
|----------|---------------------------------------------------------------------|------------|
| 5.13     | STRANDVISES.....                                                    | 5-42       |
| 5.14     | POLE ATTACHMENT ILLUSTRATIONS .....                                 | 5-43       |
| 5.15     | NON-WOOD POLES.....                                                 | 5-47       |
| 5.15.1   | Concrete Poles .....                                                | 5-47       |
| 5.15.2   | Steel Poles.....                                                    | 5-47       |
| 5.15.3   | Fiberglass or FRC Poles .....                                       | 5-47       |
| 5.15.4   | Hardware for Non-Wood Poles.....                                    | 5-48       |
| 5.15.5   | Guys .....                                                          | 5-49       |
| 5.15.6   | Holes and Drilling.....                                             | 5-52       |
| 5.15.7   | Lag Screws and Support Straps.....                                  | 5-52       |
| 5.15.8   | Banded Hardware Attachments .....                                   | 5-53       |
| 5.16     | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO POLE HARDWARE ..... | 5-55       |
| <b>6</b> | <b>GUYING .....</b>                                                 | <b>6-1</b> |
| 6.1      | GENERAL .....                                                       | 6-1        |
| 6.2      | TYPES OF GUYS .....                                                 | 6-1        |
| 6.3      | DETERMINING LEAD AND HEIGHT .....                                   | 6-7        |
| 6.4      | DETERMINING PULL.....                                               | 6-9        |
| 6.5      | PULL FINDER DESCRIPTION.....                                        | 6-10       |
| 6.6      | PULL FINDER USE .....                                               | 6-11       |
| 6.6.1    | To Measure Pull.....                                                | 6-11       |
| 6.6.2    | To Bisect the Angle.....                                            | 6-11       |
| 6.7      | DETERMINING GUY STRAND SIZE.....                                    | 6-13       |
| 6.7.1    | Dead-End Poles .....                                                | 6-17       |
| 6.7.2    | Corner Poles .....                                                  | 6-20       |
| 6.7.3    | Sidewalk Anchor Guys .....                                          | 6-22       |
| 6.8      | BRACES AND H-FIXTURES.....                                          | 6-26       |
| 6.8.1    | Braces.....                                                         | 6-26       |
| 6.8.2    | H-Fixtures .....                                                    | 6-30       |
| 6.9      | GROUNDING AND BONDING OF GUYS .....                                 | 6-32       |
| 6.10     | NON-WOOD POLES.....                                                 | 6-33       |
| <b>7</b> | <b>INSULATING GUYS .....</b>                                        | <b>7-1</b> |
| 7.1      | GENERAL .....                                                       | 7-1        |
| 7.2      | SIZES AND RATINGS OF STRAIN INSULATORS .....                        | 7-2        |
| 7.3      | LOCATING INSULATORS.....                                            | 7-3        |
| 7.4      | METHODS OF INSTALLING STRAIN INSULATORS.....                        | 7-9        |
| 7.5      | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO POLE HARDWARE ..... | 7-12       |
| <b>8</b> | <b>ANCHORS AND GUY RODS .....</b>                                   | <b>8-1</b> |
| 8.1      | GENERAL .....                                                       | 8-1        |
| 8.2      | FIELD OF USE.....                                                   | 8-2        |
| 8.2.1    | Average Soils.....                                                  | 8-2        |
| 8.2.2    | Rock Formations.....                                                | 8-2        |
| 8.2.3    | Swampy Areas.....                                                   | 8-3        |
| 8.3      | DESCRIPTION OF GUY RODS (WITH EXPANDING ANCHORS).....               | 8-4        |
| 8.4      | EXPANDING ANCHORS.....                                              | 8-5        |
| 8.4.1    | Installation .....                                                  | 8-7        |
| 8.5      | SCREW ANCHORS .....                                                 | 8-10       |
| 8.6      | SOIL CLASSES.....                                                   | 8-14       |

|           |                                                                                |              |
|-----------|--------------------------------------------------------------------------------|--------------|
| 8.7       | TOGGLE ANCHOR AND GUYING SYSTEM.....                                           | 8-15         |
| 8.8       | ADDING EYE TO EXISTING GUY ROD.....                                            | 8-18         |
| 8.9       | ANCHOR STRENGTH VERIFICATION.....                                              | 8-19         |
| 8.10      | REMOVAL OF ANCHORS AND GUYS.....                                               | 8-20         |
| 8.11      | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO ANCHORS.....                   | 8-21         |
| <b>9</b>  | <b>SUSPENSION STRAND - FALSE DEAD-ENDING AND SLACK SPAN CONSTRUCTION .....</b> | <b>9-1</b>   |
| 9.1       | GENERAL .....                                                                  | 9-1          |
| 9.2       | WRAP-TYPE FALSE DEAD-END.....                                                  | 9-1          |
| 9.3       | FALSE DEAD-END STRANDWISE.....                                                 | 9-4          |
| 9.4       | GUY CLAMP FALSE DEAD-END.....                                                  | 9-5          |
| 9.5       | STRANDWISE AND GUY CLAMP FALSE DEAD-END .....                                  | 9-7          |
| 9.6       | STRAND STRING TENSION .....                                                    | 9-9          |
| 9.7       | CONSTRUCTING THE SLACK SPAN.....                                               | 9-11         |
| <b>10</b> | <b>BONDING AND GROUNDING FOR AERIAL PLANT .....</b>                            | <b>10-1</b>  |
| 10.1      | BACKGROUND .....                                                               | 10-1         |
| 10.1.1    | <i>Changes in 2023 Edition of NESC.....</i>                                    | <i>10-2</i>  |
| 10.1.2    | <i>Basic Precautions.....</i>                                                  | <i>10-4</i>  |
| 10.2      | GENERAL .....                                                                  | 10-5         |
| 10.3      | METHODS OF BONDING AND GROUNDING .....                                         | 10-7         |
| 10.4      | GROUNDING GUYS .....                                                           | 10-14        |
| 10.4.1    | <i>Self-Supporting Cable .....</i>                                             | <i>10-16</i> |
| 10.4.2    | <i>Guys Not Electrically Connected Through Guy or Suspension Bolt .....</i>    | <i>10-17</i> |
| 10.5      | BONDING AND GROUNDING WHERE THERE IS NO ACCESS TO THE POWER MGN SYSTEM .....   | 10-19        |
| 10.5.1    | <i>Bonding and Grounding Where Access to Power MGN System Is Denied .....</i>  | <i>10-21</i> |
| 10.6      | BONDING METALLIC COMPONENTS OF OPTICAL CABLE TO SUPPORT STRAND .....           | 10-21        |
| 10.7      | GROUNDING AND BONDING ON METALLIC POLES.....                                   | 10-22        |
| 10.8      | GROUNDING AND BONDING FOR FAULT MANAGED POWER SYSTEM CIRCUITS .....            | 10-23        |
| 10.9      | GROUND RODS .....                                                              | 10-24        |
| 10.10     | INFORMATIVE REFERENCES FOR BONDING AND GROUNDING OF AERIAL PLANT .....         | 10-25        |
| <b>11</b> | <b>IDENTIFICATION MARKERS FOR AERIAL CABLE, GUYS AND EQUIPMENT.....</b>        | <b>11-1</b>  |
| 11.1      | GENERAL MARKING INFORMATION.....                                               | 11-1         |
| 11.2      | AERIAL CABLE MARKING.....                                                      | 11-2         |
| 11.3      | CABLE AND EQUIPMENT IDENTIFICATION MARKERS .....                               | 11-3         |
| 11.4      | INSTALLATION OF CABLE AND EQUIPMENT MARKERS .....                              | 11-6         |
| 11.5      | GUY MARKERS.....                                                               | 11-7         |
| 11.6      | WIRELESS ANTENNAS AND EQUIPMENT .....                                          | 11-9         |
| 11.7      | INFORMATIVE REFERENCES.....                                                    | 11-9         |
| <b>12</b> | <b>POLE TESTING AND INSPECTION .....</b>                                       | <b>12-1</b>  |
| 12.1      | POLE TESTING PRIOR TO WORK OPERATIONS .....                                    | 12-1         |
| 12.1.1    | <i>Congested Poles.....</i>                                                    | <i>12-3</i>  |
| 12.2      | CONDITIONS REQUIRING NO PHYSICAL TESTING OR SUPPLEMENTARY SUPPORT .....        | 12-5         |
| 12.3      | PHYSICAL TESTING TECHNIQUES FOR EXAMINING POLES .....                          | 12-6         |
| 12.3.1    | <i>Sound Test .....</i>                                                        | <i>12-6</i>  |
| 12.3.2    | <i>Prod Test.....</i>                                                          | <i>12-6</i>  |
| 12.3.3    | <i>Prod Test - Below Groundline Inspection.....</i>                            | <i>12-7</i>  |
| 12.3.4    | <i>Hand Line or Pike Test .....</i>                                            | <i>12-8</i>  |

|           |                                                                             |             |
|-----------|-----------------------------------------------------------------------------|-------------|
| 12.3.5    | <i>Consequences of Physical Tests</i> .....                                 | 12-8        |
| 12.4      | MEASURING EXTENT AND EFFECT OF DECAY .....                                  | 12-9        |
| 12.4.1    | <i>Internal Examination of Pole - Hook Probe in Drilled Hole</i> .....      | 12-9        |
| 12.4.2    | <i>Wood Pole Decay Patterns</i> .....                                       | 12-10       |
| 12.4.3    | <i>Deductions for Defects</i> .....                                         | 12-12       |
| 12.4.4    | <i>Critical Pole Section and Required Circumferences</i> .....              | 12-17       |
| 12.4.5    | <i>Pole Tags - General</i> .....                                            | 12-20       |
| 12.4.6    | <i>Tag Descriptions</i> .....                                               | 12-20       |
| 12.5      | WOODEN POLE INSPECTION PROGRAMS .....                                       | 12-22       |
| 12.5.1    | <i>Structural Reliability</i> .....                                         | 12-22       |
| 12.5.2    | <i>Pole Decay Background</i> .....                                          | 12-23       |
| 12.5.3    | <i>Inspection Program – General</i> .....                                   | 12-24       |
| 12.5.4    | <i>Inspection Selection Guidelines</i> .....                                | 12-27       |
| 12.5.5    | <i>Basic Training for Inspection and Testing</i> .....                      | 12-28       |
| 12.5.6    | <i>Specialized Training</i> .....                                           | 12-28       |
| 12.5.7    | <i>Visual and Physical Tests</i> .....                                      | 12-30       |
| 12.5.8    | <i>Documentation</i> .....                                                  | 12-31       |
| 12.6      | NON-WOOD POLES .....                                                        | 12-33       |
| 12.6.1    | <i>Visual Inspection</i> .....                                              | 12-33       |
| 12.7      | INFORMATIVE REFERENCES FOR UTILITY POLES .....                              | 12-35       |
| <b>13</b> | <b>POLE LOADING AND STRENGTH REQUIREMENTS</b> .....                         | <b>13-1</b> |
| 13.1      | GENERAL .....                                                               | 13-1        |
| 13.2      | WOOD POLE CLASS LOADS (ANSI O5.1) .....                                     | 13-2        |
| 13.3      | NESC STORM LOADING REQUIREMENTS .....                                       | 13-3        |
| 13.4      | NESC WIND MAPS AND LOAD FACTORS FOR 2023 .....                              | 13-7        |
| 13.5      | LOAD FACTORS AND STRENGTH FACTORS .....                                     | 13-8        |
| 13.6      | GRADE OF CONSTRUCTION .....                                                 | 13-9        |
| 13.7      | APPLICATION .....                                                           | 13-12       |
| 13.8      | DEPTH OF SET .....                                                          | 13-13       |
| 13.9      | CONDITIONS OF POTENTIAL CONCERN .....                                       | 13-15       |
| 13.10     | POLE LOADING CALCULATIONS AND PROPOSED GUIDELINES .....                     | 13-16       |
| 13.10.1   | <i>Background and General Review</i> .....                                  | 13-16       |
| 13.10.2   | <i>Overlashing Case Scenario</i> .....                                      | 13-20       |
| 13.10.3   | <i>Guidelines for Overlashing – Tangent, Angle and Dead End Poles</i> ..... | 13-22       |
| 13.10.4   | <i>Summary Over-Lash Guidelines</i> .....                                   | 13-28       |
| 13.11     | NON-WOOD POLE FACTORS .....                                                 | 13-29       |
| 13.12     | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO POLE HARDWARE .....         | 13-31       |
| <b>14</b> | <b>SUPPLY EQUIPMENT IN OR NEAR THE COMMUNICATIONS SPACE</b> .....           | <b>14-1</b> |
| 14.1      | GENERAL .....                                                               | 14-1        |
| 14.2      | METERED, UNMETERED AND SPAN POWERING .....                                  | 14-2        |
| 14.2.1    | <i>Background - Powering for Communications Circuits</i> .....              | 14-3        |
| 14.3      | POWER SUPPLIES .....                                                        | 14-7        |
| 14.3.1    | <i>Power Supply Grounding</i> .....                                         | 14-8        |
| 14.4      | LOCATIONS OF AMPLIFIERS SERVING COAXIAL NETWORKS .....                      | 14-14       |
| 14.5      | COMMUNICATIONS ANTENNA AND ASSOCIATED WIRELESS EQUIPMENT .....              | 14-15       |
| 14.6      | SUPPLY FACILITIES FOR POLE TOP FACILITIES .....                             | 14-16       |
| 14.7      | SUPPLY FACILITIES IN LOCATIONS NEAR COMMUNICATIONS SPACE .....              | 14-17       |
| 14.8      | REFERENCES FOR POWER SUPPLIES FOR COMMUNICATIONS EQUIPMENT .....            | 14-19       |

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|           |                                                                                                  |             |
|-----------|--------------------------------------------------------------------------------------------------|-------------|
| <b>15</b> | <b>WIRELESS FACILITIES.....</b>                                                                  | <b>15-1</b> |
| 15.1      | GENERAL OVERVIEW.....                                                                            | 15-1        |
| 15.1.1    | <i>Network Components (or Elements).....</i>                                                     | 15-5        |
| 15.1.2    | <i>Regulatory Perspective .....</i>                                                              | 15-6        |
| 15.2      | RADIO FREQUENCY (RF) EXPOSURE .....                                                              | 15-7        |
| 15.2.1    | <i>FCC Exposure Guidelines.....</i>                                                              | 15-8        |
| 15.2.2    | <i>OSHA Exposure Regulations and Guidelines.....</i>                                             | 15-9        |
| 15.2.3    | <i>Radio Frequency Safety Programs (RFSP).....</i>                                               | 15-11       |
| 15.2.4    | <i>RF Exposure Analysis.....</i>                                                                 | 15-12       |
| 15.3      | POLE MARKING AND PRODUCT REQUIREMENTS .....                                                      | 15-15       |
| 15.3.1    | <i>Pole Markings.....</i>                                                                        | 15-15       |
| 15.3.2    | <i>IEEE C95 Practices and Guidelines .....</i>                                                   | 15-16       |
| 15.4      | MECHANICAL, ELECTRICAL AND SPATIAL CONCERNS.....                                                 | 15-20       |
| 15.4.1    | <i>Ground Clearances.....</i>                                                                    | 15-21       |
| 15.4.2    | <i>Separation from Supply and Other Communications Lines .....</i>                               | 15-22       |
| 15.4.3    | <i>Other Clearances and Separations .....</i>                                                    | 15-23       |
| 15.4.4    | <i>Climbing Space.....</i>                                                                       | 15-27       |
| 15.4.5    | <i>Working Space .....</i>                                                                       | 15-29       |
| 15.4.6    | <i>Heat Dissipation.....</i>                                                                     | 15-30       |
| 15.4.7    | <i>Powering and Grounding.....</i>                                                               | 15-31       |
| 15.4.8    | <i>Cables and Attachment Hardware .....</i>                                                      | 15-31       |
| 15.4.9    | <i>Attachment Structures.....</i>                                                                | 15-32       |
| 15.5      | LOCATION CHOICES FOR ANTENNA/WIRELESS EQUIPMENT .....                                            | 15-34       |
| 15.5.1    | <i>Antenna Placement on Light Poles .....</i>                                                    | 15-36       |
| 15.6      | SUMMARY .....                                                                                    | 15-39       |
| 15.6.1    | <i>General Guidelines.....</i>                                                                   | 15-39       |
| 15.6.2    | <i>Grounding and Bonding.....</i>                                                                | 15-45       |
| 15.6.3    | <i>Pole Loading Considerations.....</i>                                                          | 15-45       |
| 15.6.4    | <i>Attachment Hardware .....</i>                                                                 | 15-46       |
| 15.7      | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO WIRELESS FACILITIES .....                        | 15-47       |
|           | <i>Wireless Facilities - Infrastructure .....</i>                                                | 15-47       |
|           | <i>Equipment - Environmental and Physical Protection (NEBS) .....</i>                            | 15-48       |
|           | <i>Attachment Hardware.....</i>                                                                  | 15-48       |
|           | <i>Governmental Documents - OSHA and FCC Related .....</i>                                       | 15-48       |
|           | <i>IEEE Standards .....</i>                                                                      | 15-49       |
|           | <i>ATIS (Alliance for Telecommunications Industry Solutions) Standards.....</i>                  | 15-50       |
| <b>16</b> | <b>GENERAL PRECAUTIONS AND WORK RULES FOR MANHOLES .....</b>                                     | <b>16-1</b> |
| 16.1      | GENERAL .....                                                                                    | 16-1        |
| 16.1.1    | <i>Handholes and Other Vaults.....</i>                                                           | 16-1        |
| 16.2      | GENERAL PRECAUTIONS AND WORK RULES .....                                                         | 16-2        |
| 16.2.1    | <i>Power and Communications in Manhole/Handhole.....</i>                                         | 16-3        |
| 16.2.2    | <i>Corrosion in Manholes.....</i>                                                                | 16-5        |
| 16.3      | NORMATIVE AND INFORMATIVE REFERENCES RELATED TO MANHOLES .....                                   | 16-7        |
| <b>17</b> | <b>TESTING MANHOLE ATMOSPHERE AND VENTILATING MANHOLE .....</b>                                  | <b>17-1</b> |
| 17.1      | GENERAL PRECAUTIONS.....                                                                         | 17-1        |
| 17.1.1    | <i>Tents.....</i>                                                                                | 17-2        |
| 17.1.2    | <i>Open Flames and Furnaces.....</i>                                                             | 17-2        |
| 17.1.3    | <i>Fusion Splicing Optical Fiber Cable in Cable Entrance Facilities (CEFs) and Manholes.....</i> | 17-2        |

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|           |                                                                   |             |
|-----------|-------------------------------------------------------------------|-------------|
| 17.1.4    | Radon in Manholes .....                                           | 17-3        |
| 17.2      | GAS INDICATORS AND MONITORS.....                                  | 17-3        |
| 17.2.1    | Non-Continuous Gas Indicators (Hand-Aspirated).....               | 17-4        |
| 17.2.2    | Continuous Gas Monitors .....                                     | 17-5        |
| 17.3      | BLOWERS.....                                                      | 17-6        |
| 17.3.1    | Blower Capacities .....                                           | 17-6        |
| 17.3.2    | Blower Maintenance.....                                           | 17-7        |
| 17.4      | SETUPS FOR TESTING AND PURGING MANHOLES .....                     | 17-8        |
| 17.4.1    | General .....                                                     | 17-8        |
| 17.4.2    | Conventional Manholes .....                                       | 17-8        |
| 17.4.3    | Irregular-Shaped Manholes .....                                   | 17-10       |
| 17.4.4    | Offset-Access Manholes.....                                       | 17-11       |
| 17.4.5    | Deep-Neck Manholes.....                                           | 17-13       |
| 17.5      | PURGE TIMES .....                                                 | 17-16       |
| 17.5.1    | Alignment Charts .....                                            | 17-16       |
| 17.5.2    | Determining Purge Times .....                                     | 17-19       |
| 17.6      | TESTING, PURGING, AND VENTILATING MANHOLES .....                  | 17-20       |
| 17.6.1    | General .....                                                     | 17-20       |
| 17.6.2    | Initial Test Prior to Entry .....                                 | 17-21       |
| 17.6.3    | Tests at Entry .....                                              | 17-22       |
| 17.6.4    | Tests and Precautions During Work Operations.....                 | 17-23       |
| 17.7      | TESTING CABLE ENTRANCE FACILITIES (CEFs) FOR COMBUSTIBLE GAS..... | 17-28       |
| 17.7.1    | General .....                                                     | 17-28       |
| 17.7.2    | Test Procedures .....                                             | 17-28       |
| 17.7.3    | Testing Unattended Buildings for Combustible Gas .....            | 17-29       |
| 17.7.4    | Water Discharge from Manhole .....                                | 17-29       |
| <b>18</b> | <b>BONDING CABLES IN MANHOLES AND HANDHOLES .....</b>             | <b>18-1</b> |
| 18.1      | GENERAL .....                                                     | 18-1        |
| 18.2      | LOCATION OF BONDS .....                                           | 18-1        |
| 18.3      | PLACING BONDS .....                                               | 18-2        |
| 18.4      | CONNECTION TO GROUND (EARTH) .....                                | 18-2        |
| 18.5      | BONDING IN HANDHOLES.....                                         | 18-3        |
| <b>19</b> | <b>IDENTIFICATION MARKERS FOR UNDERGROUND CABLE .....</b>         | <b>19-1</b> |
| 19.1      | GENERAL .....                                                     | 19-1        |
| 19.2      | DESCRIPTION.....                                                  | 19-2        |
| 19.3      | CABLE TAG LOCATION .....                                          | 19-2        |
| 19.4      | METHOD OF INSTALLING TAGS.....                                    | 19-3        |
| 19.5      | OTHER IDENTIFICATION MARKERS .....                                | 19-5        |
| 19.6      | LOCATING TECHNOLOGIES FOR BURIED AND UNDERGROUND PLANT .....      | 19-5        |
| <b>20</b> | <b>SEALING CONDUITS AND DUCTS.....</b>                            | <b>20-1</b> |
| 20.1      | GENERAL DEFINITIONS .....                                         | 20-1        |
| 20.2      | GENERAL SEALING .....                                             | 20-2        |
| 20.3      | WHERE SEALS ARE REQUIRED.....                                     | 20-5        |
| 20.4      | RUBBER DUCT PLUG - DESCRIPTION.....                               | 20-6        |
| 20.4.1    | Rubber Duct Plugs for Multiple Cables in a Conduit .....          | 20-12       |
| 20.5      | INSTALLING RUBBER DUCT PLUGS.....                                 | 20-12       |
| 20.6      | REMOVING RUBBER DUCT PLUGS.....                                   | 20-15       |

|           |                                                                       |             |
|-----------|-----------------------------------------------------------------------|-------------|
| 20.7      | DESCRIPTION OF CAULKING MATERIALS.....                                | 20-18       |
| 20.8      | INSTALLING CAULKING MATERIAL.....                                     | 20-19       |
| 20.9      | INSTALLING PLASTIC DUCT SEALS.....                                    | 20-21       |
| 20.10     | WOODEN DUCT PLUGS.....                                                | 20-21       |
| 20.11     | PLASTIC CONDUIT PLUGS – DESCRIPTION AND USE.....                      | 20-21       |
| 20.12     | DUCT PLUGS USING FOAMS.....                                           | 20-23       |
| 20.13     | DUCTLINER (INNERDUCT).....                                            | 20-25       |
| 20.14     | MICRODUCTS.....                                                       | 20-25       |
| 20.15     | REFERENCES RELATED TO CONDUITS, DUCTS, SEALANTS AND ENCAPSULANTS..... | 20-26       |
| <b>21</b> | <b>BURIED PLANT CONSTRUCTION - GENERAL .....</b>                      | <b>21-1</b> |
| 21.1      | CONSTRUCTION OF FACILITIES - GENERAL.....                             | 21-1        |
| 21.2      | CONSTRUCTION SPECIFICATIONS .....                                     | 21-2        |
| 21.2.1    | <i>Random Separation of Communications Cables.....</i>                | 21-3        |
| 21.2.2    | <i>Planned Separation of Cables.....</i>                              | 21-7        |
| 21.2.3    | <i>Bonding and Grounding.....</i>                                     | 21-8        |
| 21.2.4    | <i>Bonding and Grounding of Buried Optical Fiber Cable .....</i>      | 21-9        |
| 21.2.5    | <i>Conduit Size .....</i>                                             | 21-10       |
| 21.2.6    | <i>Depth of Buried Cable.....</i>                                     | 21-12       |
| 21.2.7    | <i>Trench Bottom and Backfill.....</i>                                | 21-13       |
| 21.2.8    | <i>Soil and Dust Management .....</i>                                 | 21-13       |
| 21.2.9    | <i>Trouble and Maintenance Procedures.....</i>                        | 21-14       |
| 21.2.10   | <i>Joint-Use Buried Networks - Buried Duct Networks (BDNs).....</i>   | 21-15       |
| 21.3      | CABLE PLACING.....                                                    | 21-16       |
| 21.4      | SPLICE POINT EXCAVATIONS .....                                        | 21-17       |
| 21.5      | HANDHOLES.....                                                        | 21-17       |
| 21.5.1    | <i>Applications .....</i>                                             | 21-17       |
| 21.5.2    | <i>Installation.....</i>                                              | 21-22       |
| 21.5.3    | <i>Bonding in Handholes.....</i>                                      | 21-23       |
| 21.6      | BACKFILLING AND GROUND RESTORATION .....                              | 21-23       |
| 21.7      | PERMANENT MARKINGS.....                                               | 21-24       |
| 21.8      | U-TYPE CABLE GUARDS.....                                              | 21-25       |
| 21.9      | CONDUITS FOR VERTICAL RISERS .....                                    | 21-28       |
| 21.10     | INFORMATIVE REFERENCES RELATED TO DIRECT-BURIED PLANT.....            | 21-29       |
| <b>22</b> | <b>HIGH-AIR-SPEED BLOWN CABLE (HASB) INSTALLATION SYSTEM.....</b>     | <b>22-1</b> |
| 22.1      | GENERAL .....                                                         | 22-1        |
| 22.2      | PRODUCT DESCRIPTION .....                                             | 22-2        |
| 22.2.1    | <i>Principle of Operation.....</i>                                    | 22-2        |
| 22.2.2    | <i>Equipment Description.....</i>                                     | 22-5        |
| 22.3      | HASB METHOD OF CABLE PLACEMENT .....                                  | 22-6        |
| 22.3.1    | <i>Preparation.....</i>                                               | 22-6        |
| 22.3.2    | <i>HASB Set-Up.....</i>                                               | 22-8        |
| 22.3.3    | <i>Cable Installation.....</i>                                        | 22-9        |
| <b>23</b> | <b>DIRECT-BURIED INNERDUCT CONSTRUCTION GUIDELINES .....</b>          | <b>23-1</b> |
| 23.1      | GENERAL .....                                                         | 23-1        |
| 23.2      | APPLICATIONS .....                                                    | 23-1        |
| 23.3      | DUCT AND INNERDUCT TYPES.....                                         | 23-2        |
| 23.3.1    | <i>General Considerations.....</i>                                    | 23-2        |



|           |                                                                              |             |
|-----------|------------------------------------------------------------------------------|-------------|
| 23.3.2    | <i>Metallic Service Wire</i> .....                                           | 23-3        |
| 23.3.3    | <i>Distribution</i> .....                                                    | 23-3        |
| 23.4      | INNERDUCT INSTALLATION METHODS AND PRACTICES .....                           | 23-4        |
| 23.4.1    | <i>Planning</i> .....                                                        | 23-4        |
| 23.4.2    | <i>General Considerations</i> .....                                          | 23-4        |
| 23.4.3    | <i>Trenching</i> .....                                                       | 23-5        |
| 23.5      | MICROTRENCHING IN URBAN ENVIRONMENTS .....                                   | 23-6        |
| 23.6      | PLOWING .....                                                                | 23-9        |
| 23.7      | DIRECTIONAL DRILLING .....                                                   | 23-10       |
| 23.8      | CABLE PULLING .....                                                          | 23-10       |
| 23.8.1    | <i>Pulling Tension</i> .....                                                 | 23-12       |
| 23.8.2    | <i>Optical Fiber Cable Case Studies</i> .....                                | 23-17       |
| 23.9      | INFORMATIVE REFERENCES RELATED TO DIRECT-BURIED APPLICATIONS .....           | 23-23       |
| <b>24</b> | <b>HORIZONTAL DIRECTIONAL DRILLING (HDD)</b> .....                           | <b>24-1</b> |
| 24.1      | GENERAL .....                                                                | 24-1        |
| 24.2      | DESCRIPTION .....                                                            | 24-2        |
| 24.3      | PRELIMINARY SITE INVESTIGATION .....                                         | 24-5        |
| 24.3.1    | <i>Existing Below-Ground Utilities</i> .....                                 | 24-5        |
| 24.3.2    | <i>Surface Investigation</i> .....                                           | 24-6        |
| 24.3.3    | <i>Subsurface Investigation</i> .....                                        | 24-6        |
| 24.4      | SAFETY DURING HDD OPERATION .....                                            | 24-7        |
| 24.5      | ENVIRONMENTAL CONSIDERATIONS .....                                           | 24-10       |
| 24.6      | REGULATIONS AND DAMAGE PREVENTION .....                                      | 24-11       |
| 24.6.1    | <i>Locating and Marking</i> .....                                            | 24-12       |
| 24.7      | PRODUCT PIPE (INNERDUCT) - PLACEMENT DISTANCES .....                         | 24-14       |
| 24.8      | BORE PATH LAYOUT AND DESIGN .....                                            | 24-16       |
| 24.8.1    | <i>Bore Path Profile/Trajectory (Vertical Plane)</i> .....                   | 24-17       |
| 24.8.2    | <i>Bore Path (Horizontal) Planar Trajectory</i> .....                        | 24-19       |
| 24.8.3    | <i>Overall Bore Path Layout</i> .....                                        | 24-19       |
| 24.9      | IMPLEMENTATION .....                                                         | 24-20       |
| 24.9.1    | <i>Tracking and Locating</i> .....                                           | 24-22       |
| 24.9.2    | <i>Reaming</i> .....                                                         | 24-23       |
| 24.9.3    | <i>Gripping and Pulling</i> .....                                            | 24-23       |
| 24.10     | INSPECTION AND SITE CLEANUP .....                                            | 24-25       |
| 24.11     | INFORMATIVE REFERENCES RELATED TO DIRECTIONAL DRILLING .....                 | 24-26       |
| <b>25</b> | <b>BONDING AND GROUNDING - DROP CABLES AND SERVICE WIRES</b> .....           | <b>25-1</b> |
| 25.1      | GENERAL .....                                                                | 25-1        |
| 25.1.1    | <i>Changes in 2017/2023 Editions of NESC and NEC</i> .....                   | 25-1        |
| 25.1.2    | <i>Grounding Rods and Locations</i> .....                                    | 25-2        |
| 25.1.3    | <i>New Expanded Article 840</i> .....                                        | 25-3        |
| 25.1.4    | <i>Historical Perspective - Changes in the 2011 NEC (from Issue 5)</i> ..... | 25-3        |
| 25.1.5    | <i>Grounding and Bonding Terminology</i> .....                               | 25-4        |
| 25.2      | PURPOSE OF GROUNDING (AND BONDING) .....                                     | 25-6        |
| 25.2.1    | <i>General Work Rules and Precautions</i> .....                              | 25-6        |
| 25.3      | BONDING AND GROUNDING AT CUSTOMER PREMISES .....                             | 25-9        |
| 25.3.1    | <i>NEC Perspective of Grounding at Service Demarcations</i> .....            | 25-9        |
| 25.3.2    | <i>Grounding Electrode Choices</i> .....                                     | 25-12       |
| 25.3.3    | <i>Ground Rods – Recommended Materials, Designs and Diameters</i> .....      | 25-17       |

|           |                                                                                             |             |
|-----------|---------------------------------------------------------------------------------------------|-------------|
| 25.3.4    | <i>Reference Materials Used for Section 25.3.3 Discussions</i>                              | 25-23       |
| 25.3.5    | <i>Grounding of Metallic Components of Fiber Cable</i>                                      | 25-24       |
| 25.3.6    | <i>Grounding of Antenna Lead-In and Other Components of Local Communications Antenna</i>    | 25-26       |
| 25.4      | BASIC GROUNDING METHODS AND PROCEDURES                                                      | 25-29       |
| 25.4.1    | <i>Ground Wires</i>                                                                         | 25-31       |
| 25.4.2    | <i>Grounding Clamps</i>                                                                     | 25-32       |
| 25.5      | GROUND TAGS                                                                                 | 25-34       |
| 25.6      | GROUNDING REQUIREMENTS                                                                      | 25-35       |
| 25.7      | GROUNDING NIDS IN DETACHED STRUCTURES                                                       | 25-36       |
| 25.8      | VERIFICATION OF THE GROUNDING AND BONDING CONNECTIONS                                       | 25-36       |
| 25.8.1    | <i>Test Method 1</i>                                                                        | 25-37       |
| 25.8.2    | <i>Test Procedure:</i>                                                                      | 25-38       |
| 25.8.3    | <i>Test Method 2</i>                                                                        | 25-38       |
| 25.8.4    | <i>Test Procedure:</i>                                                                      | 25-39       |
| 25.9      | GROUNDING AT MOBILE HOMES AND TRAILERS                                                      | 25-39       |
| 25.9.1    | <i>Overview</i>                                                                             | 25-39       |
| 25.9.2    | <i>Grounding in Mobile Home/Trailers - NID Placement Considerations</i>                     | 25-39       |
| 25.9.3    | <i>Mobile Home and Trailers: Grounding Options</i>                                          | 25-41       |
| 25.10     | EXAMPLES OF GROUNDING CONFIGURATIONS                                                        | 25-42       |
| <b>26</b> | <b>JOINT USE AGREEMENTS AND CALIFORNIA GENERAL ORDERS</b>                                   | <b>26-1</b> |
| 26.1      | BACKGROUND                                                                                  | 26-1        |
| 26.2      | FEATURES, FORMAT AND ELEMENTS OF JOINT-USE AGREEMENTS                                       | 26-3        |
| 26.2.1    | <i>Front Material – Introduction, Table of Contents, Recital Clauses</i>                    | 26-4        |
| 26.2.2    | <i>Definitions Clauses</i>                                                                  | 26-4        |
| 26.2.3    | <i>Scope Clauses</i>                                                                        | 26-5        |
| 26.2.4    | <i>Financial Related Clauses – Fees, Charges, Insurance Related</i>                         | 26-6        |
| 26.2.5    | <i>Clauses with Operational Consequences</i>                                                | 26-8        |
| 26.2.6    | <i>Administrative and Contingency Clauses</i>                                               | 26-13       |
| 26.2.7    | <i>Catchall and Miscellaneous Clauses</i>                                                   | 26-14       |
| 26.3      | JUA ROLES IN A WIRELESS ATTACHMENT APPROVAL                                                 | 26-15       |
| 26.4      | CALIFORNIA GENERAL ORDER 95 AND 128                                                         | 26-19       |
| 26.4.1    | <i>GO 95 Rule Considerations and Commentary on Practices</i>                                | 26-24       |
| 26.4.2    | <i>GO 128 Considerations and Commentary on Practices</i>                                    | 26-28       |
| <b>27</b> | <b>OPTICAL FIBER FACILITIES (FTTX) - DEPLOYMENT</b>                                         | <b>27-1</b> |
| 27.1      | GENERAL                                                                                     | 27-1        |
| 27.1.1    | <i>Product Acceptance and Shipment</i>                                                      | 27-2        |
| 27.1.2    | <i>Security and Safety Practices</i>                                                        | 27-4        |
| 27.1.3    | <i>Optical Fiber Cable Placement</i>                                                        | 27-5        |
| 27.2      | UNDERGROUND CABLE PLACEMENT                                                                 | 27-6        |
| 27.2.1    | <i>Pre-Survey</i>                                                                           | 27-6        |
| 27.2.2    | <i>Tools and Equipment</i>                                                                  | 27-7        |
| 27.2.3    | <i>Fusion Splicing Optical Fiber Cable in Cable Entrance Facilities (CEFs) and Manholes</i> | 27-9        |
| 27.2.4    | <i>Innerduct</i>                                                                            | 27-9        |
| 27.2.5    | <i>Standard Innerduct Coupling for Pulling Method</i>                                       | 27-9        |
| 27.2.6    | <i>Occupied Conduits and Separate Ducts (Innerducts)</i>                                    | 27-14       |
| 27.2.7    | <i>Microducts and Fabric Sleeves</i>                                                        | 27-17       |
| 27.2.8    | <i>Fabric Sleeves</i>                                                                       | 27-20       |
| 27.3      | DIRECT-BURIED CABLE                                                                         | 27-21       |

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|           |                                                                                        |             |
|-----------|----------------------------------------------------------------------------------------|-------------|
| 27.3.1    | <i>Depth of Cover</i> .....                                                            | 27-21       |
| 27.3.2    | <i>Pre-Survey</i> .....                                                                | 27-23       |
| 27.3.3    | <i>Trenching Placing Method</i> .....                                                  | 27-23       |
| 27.3.4    | <i>Cable Placing</i> .....                                                             | 27-24       |
| 27.3.5    | <i>Backfilling and Ground Restoration</i> .....                                        | 27-24       |
| 27.3.6    | <i>Rollers and Guide Tubes</i> .....                                                   | 27-25       |
| 27.3.7    | <i>Optical Fiber Drop Plant - ONUs, Pedestals, and Handholes</i> .....                 | 27-26       |
| 27.4      | AERIAL CABLE PLACING METHOD .....                                                      | 27-27       |
| 27.4.1    | <i>Stationary-Reel Method (Backpull)</i> .....                                         | 27-28       |
| 27.4.2    | <i>Moving Reel Without Aerial Lift (Drive Off)</i> .....                               | 27-28       |
| 27.4.3    | <i>Moving Reel with Aerial Lift (Drive Off)</i> .....                                  | 27-29       |
| 27.4.4    | <i>All-Dielectric Self-Support (ADSS)</i> .....                                        | 27-29       |
| 27.5      | POLE-MOUNTED CABINETS .....                                                            | 27-30       |
| 27.5.1    | <i>Pre-Planning</i> .....                                                              | 27-31       |
| 27.5.2    | <i>Mounting the Cabinet</i> .....                                                      | 27-31       |
| 27.6      | GROUND-MOUNTED CABINETS .....                                                          | 27-31       |
| 27.7      | FACTORY INSTALLED TERMINATION SYSTEM (FITS) .....                                      | 27-32       |
| 27.7.1    | <i>General Considerations</i> .....                                                    | 27-32       |
| 27.7.2    | <i>Aerial FITS Plant</i> .....                                                         | 27-32       |
| 27.7.3    | <i>Buried FITS</i> .....                                                               | 27-33       |
| 27.8      | PREMISES-POWERED BROADBAND COMMUNICATIONS SYSTEMS .....                                | 27-34       |
| <b>28</b> | <b>SYMBOLS FOR GRID AND MAPPING DIAGRAMS</b> .....                                     | <b>28-1</b> |
| 28.1      | GENERAL .....                                                                          | 28-1        |
| 28.1.1    | <i>Commentary</i> .....                                                                | 28-1        |
| 28.2      | DRAFTING PRACTICES APPLICABLE TO GRAPHIC SYMBOLS .....                                 | 28-2        |
| 28.3      | AERIAL PLANT .....                                                                     | 28-3        |
| 28.3.1    | <i>Poles</i> .....                                                                     | 28-3        |
| 28.3.2    | <i>Pole Line Support Elements</i> .....                                                | 28-5        |
| 28.3.3    | <i>Cable Support Elements Stranded or Solid Messenger Items With Poles Shown</i> ..... | 28-6        |
| 28.3.4    | <i>Anchoring and Guying With Poles Shown</i> .....                                     | 28-7        |
| 28.3.5    | <i>Cross Connects</i> .....                                                            | 28-10       |
| 28.4      | UNDERGROUND AND BURIED .....                                                           | 28-10       |
| 28.5      | TERMINALS .....                                                                        | 28-13       |
| 28.6      | TELECOM METALLIC PAIR DEVICES .....                                                    | 28-14       |
| 28.7      | POWER .....                                                                            | 28-14       |
| 28.8      | HOUSE CATV DROP DESIGNATIONS WITH POLES SHOWN .....                                    | 28-15       |
| 28.9      | CATV DEVICES .....                                                                     | 28-16       |
| 28.9.1    | <i>Power Devices - Amplifiers</i> .....                                                | 28-16       |
| 28.9.2    | <i>Power Devices - Splitters</i> .....                                                 | 28-17       |
| 28.9.3    | <i>Power Devices - AC Power Block</i> .....                                            | 28-17       |
| 28.9.4    | <i>Equalizer</i> .....                                                                 | 28-18       |
| 28.9.5    | <i>Subscriber Taps</i> .....                                                           | 28-18       |
| 28.9.6    | <i>Other Powering Devices</i> .....                                                    | 28-19       |
| 28.9.7    | <i>Other Devices</i> .....                                                             | 28-20       |
| 28.9.8    | <i>Carrier Equipment</i> .....                                                         | 28-20       |
| 28.9.9    | <i>Signal Processing Locations (Antenna Site, Head-End, Hub, etc.)</i> .....           | 28-22       |
| 28.9.10   | <i>Coaxial Cables</i> .....                                                            | 28-23       |
| 28.10     | OPTICAL FIBER PLANT .....                                                              | 28-24       |

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|--------------------------------------------------------------------------------------------------------------------|------------|
| <b>APPENDIX A: CLEARANCE AND LOADING ISSUES IN NESC .....</b>                                                      | <b>A-1</b> |
| A.1    CLEARANCES.....                                                                                             | A-1        |
| A.1.1    Historical 1990 Changes.....                                                                              | A-1        |
| A.1.2    Rule 235H - Clearances Between Communications Lines.....                                                  | A-1        |
| A.1.3    Wireless Facilities - Rule 235, 238F and Other Related Rules .....                                        | A-2        |
| A.1.4    NESC Clearance Zones and Loading Districts .....                                                          | A-2        |
| <b>APPENDIX B: NESC CODE CYCLE .....</b>                                                                           | <b>B-1</b> |
| B.1    2023 NESC CODE - OVERVIEW.....                                                                              | B-1        |
| B.2    NESC CODE CYCLE SCHEDULES.....                                                                              | B-3        |
| B.3    NESC WORKING GROUPS AND POSSIBLE FUTURE ISSUES.....                                                         | B-3        |
| <b>APPENDIX C: NETWORK RESILIENCY, PLANT RELIABILITY AND POWER INTERDEPENDENCE OF COMMUNICATIONS SYSTEMS .....</b> | <b>C-1</b> |
| C.1    RESILIENCY AND RELIABILITY .....                                                                            | C-2        |
| C.2    INTERDEPENDENCE OF POWER AND COMMUNICATIONS.....                                                            | C-8        |
| C.3    CURRENT AND EMERGING TELECOM NETWORK POWER.....                                                             | C-10       |
| C.3.1    Communications Powering .....                                                                             | C-11       |
| C.4    COMMUNICATIONS IMPACTS OF HISTORICAL DISRUPTIVE EVENTS.....                                                 | C-19       |
| C.5    PROTECTIVE MEASURES.....                                                                                    | C-28       |
| Improvised Nuclear Device .....                                                                                    | C-29       |
| Aerosol Anthrax.....                                                                                               | C-30       |
| Pandemic Influenza .....                                                                                           | C-30       |
| Plague .....                                                                                                       | C-31       |
| Blister Agents .....                                                                                               | C-32       |
| Toxic Industrial Chemicals.....                                                                                    | C-32       |
| Nerve Agent .....                                                                                                  | C-33       |
| Chlorine Tank Explosion .....                                                                                      | C-33       |
| Major Earthquake .....                                                                                             | C-35       |
| Major Hurricane.....                                                                                               | C-35       |
| Radiological Dispersal Device.....                                                                                 | C-36       |
| Improvised Explosive Device.....                                                                                   | C-37       |
| Food Contamination.....                                                                                            | C-37       |
| Foreign Animal Disease .....                                                                                       | C-37       |
| Cyber Attack.....                                                                                                  | C-37       |
| C.6    SUMMARY .....                                                                                               | C-38       |
| C.7    NRIC BEST PRACTICES .....                                                                                   | C-40       |
| C.8    HISTORICAL WORK RULES.....                                                                                  | C-50       |
| <b>APPENDIX D: REFERENCES.....</b>                                                                                 | <b>D-1</b> |
| D.1    GR DOCUMENTS.....                                                                                           | D-1        |
| D.2    NON-GR DOCUMENTS.....                                                                                       | D-3        |
| D.3    TO OBTAIN ADDITIONAL REFERENCE MATERIALS.....                                                               | D-11       |
| D.4    FAMILY OF REQUIREMENTS (FR) AND FAMILY OF DOCUMENTS (FD) SETS.....                                          | D-11       |
| D.5    REFERENCE NOTES .....                                                                                       | D-12       |
| <b>APPENDIX E: GLOSSARY .....</b>                                                                                  | <b>E-1</b> |

## List of Figures

|                                                                                                                         |      |
|-------------------------------------------------------------------------------------------------------------------------|------|
| FIGURE 2-1 VARIOUS TYPES OF POWER CONDUCTORS.....                                                                       | 2-12 |
| FIGURE 3-1 CLEARANCE BETWEEN LICENSEE-OWNED AND COMMUNICATIONS COMPANY CABLES.....                                      | 3-4  |
| FIGURE 3-2 VERTICAL SEPARATION BETWEEN STRAND-MOUNTED EQUIPMENT AND OTHER CABLE.....                                    | 3-4  |
| FIGURE 3-3 CLEARANCES ON JOINT-USE POLES.....                                                                           | 3-10 |
| FIGURE-3-4 CLEARANCES BETWEEN POWER TRANSFORMER VOLTAGE REGULATOR OR CAPACITOR<br>AND COMMUNICATIONS WIRE OR CABLE..... | 3-11 |
| FIGURE 3-5 CLEARANCE BETWEEN STREETLIGHT BRACKET AND COMMUNICATIONS CABLE .....                                         | 3-12 |
| FIGURE 3-6 SPACER CABLES.....                                                                                           | 3-17 |
| FIGURE 3-7 TRIPLEX POWER CABLE.....                                                                                     | 3-18 |
| FIGURE 3-8 MIDSPAN CLEARANCE .....                                                                                      | 3-18 |
| FIGURE 3-9 VERTICAL CLEARANCE OVER PUBLIC ROAD .....                                                                    | 3-22 |
| FIGURE 3-10 CLIMBING SPACE WHERE DROP WIRES ARE PRESENT .....                                                           | 3-32 |
| FIGURE 3-11 ROOF ANCHOR METHOD (NOT RECOMMENDED).....                                                                   | 3-35 |
| FIGURE 3-12 COMMUNICATIONS SERVICE MAST OPTIONS.....                                                                    | 3-36 |
| FIGURE 5-1 CABLE-SUSPENSION CLAMP .....                                                                                 | 5-18 |
| FIGURE 5-2 CORNER-SUSPENSION CLAMP.....                                                                                 | 5-18 |
| FIGURE 5-3 C CABLE CLAMP .....                                                                                          | 5-19 |
| FIGURE 5-4 SUSPENSION BOLTS FOR SUPPORTING SUSPENSION CLAMPS.....                                                       | 5-20 |
| FIGURE 5-5 CABLE-SUSPENSION SCREW .....                                                                                 | 5-22 |
| FIGURE 5-6 INSTALLED CABLE-SUSPENSION SCREW .....                                                                       | 5-22 |
| FIGURE 5-7 REINFORCING STRAP .....                                                                                      | 5-23 |
| FIGURE 5-8 INSTALLING REINFORCING STRAP USING DRIVE SCREW.....                                                          | 5-24 |
| FIGURE 5-9 INSTALLING REINFORCING STRAP USING BOLT .....                                                                | 5-25 |
| FIGURE 5-10 NUT AND WASHER USED TO SPACE REINFORCING STRAP.....                                                         | 5-26 |
| FIGURE 5-11 REINFORCING LINK .....                                                                                      | 5-26 |
| FIGURE 5-12 REINFORCING LINKS INSTALLED ON POLE .....                                                                   | 5-28 |
| FIGURE 5-13 REINFORCING LINKS INSTALLED AT GUARD ARM LOCATION ON POLE.....                                              | 5-28 |
| FIGURE 5-14 B- AND C-TYPE GUY HOOKS.....                                                                                | 5-30 |
| FIGURE 5-15 BRANCH STRAND TERMINATION - 6.6 M OR 6 M MAIN STRAND .....                                                  | 5-31 |
| FIGURE 5-16 INSTALLED GUY HOOKS .....                                                                                   | 5-32 |
| FIGURE 5-17 GUY HOOKS INSTALLED - POLE-TO-POLE GUY.....                                                                 | 5-32 |
| FIGURE 5-18 THIMBLE EYE BOLTS .....                                                                                     | 5-33 |
| FIGURE 5-19 INSTALLATION OF ANGLED (BENT) THIMBLE EYE BOLT.....                                                         | 5-34 |
| FIGURE 5-20 INSTALLATION OF A STRAIGHT THIMBLE EYE BOLT .....                                                           | 5-35 |
| FIGURE 5-21 GUY STRAPS.....                                                                                             | 5-36 |
| FIGURE 5-22 ARRANGEMENT OF GUY CLAMP .....                                                                              | 5-38 |
| FIGURE 5-23 SERVING THE GUY TAIL.....                                                                                   | 5-38 |
| FIGURE 5-24 APPLYING SECOND LEG .....                                                                                   | 5-40 |
| FIGURE 5-25 APPLYING FIRST LEG .....                                                                                    | 5-40 |
| FIGURE 5-26 GUY INSTALLED USING GUY HOOKS AND GUY GRIP .....                                                            | 5-41 |
| FIGURE 5-27 STRANDWISE .....                                                                                            | 5-42 |
| FIGURE 5-28 POLE ATTACHMENT FOR 6.6 M OR 6 M SUSPENSION STRAND WITHOUT REINFORCING STRAP.....                           | 5-43 |
| FIGURE 5-29 POLE ATTACHMENT WITH REINFORCING STRAP ATTACHED WITH DRIVE SCREW .....                                      | 5-44 |
| FIGURE 5-30 POLE ATTACHMENT WITH REINFORCING STRAP ATTACHED WITH SUSPENSION BOLT .....                                  | 5-45 |
| FIGURE 5-31 6.6 M OR 6 M SUSPENSION STRAND – PULL AWAY FROM POLE – 10 FEET OR MORE .....                                | 5-45 |
| FIGURE 5-32 6.6 M OR 6 M SUSPENSION STRAND WITH REINFORCING STRAP – PULL TOWARD POLE – 10 FEET OR MORE .....            | 5-46 |
| FIGURE 6-1 SIDE GUY.....                                                                                                | 6-2  |
| FIGURE 6-2 SIDE GUY.....                                                                                                | 6-3  |

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|                                                                                                                                        |      |
|----------------------------------------------------------------------------------------------------------------------------------------|------|
| FIGURE 6-3 POLE-TO-STUB GUY .....                                                                                                      | 6-4  |
| FIGURE 6-4 POLE-TO-POLE GUY.....                                                                                                       | 6-5  |
| FIGURE 6-5 SIDEWALK ANCHOR GUY .....                                                                                                   | 6-6  |
| FIGURE 6-6 LEAD AND HEIGHT MEASUREMENTS .....                                                                                          | 6-7  |
| FIGURE 6-7 LEAD AND HEIGHT MEASUREMENTS FOR SIDEWALK ANCHOR GUY .....                                                                  | 6-8  |
| FIGURE 6-8 MEASURING CORNER PULL (TAPING).....                                                                                         | 6-9  |
| FIGURE 6-9 PULL FINDER .....                                                                                                           | 6-10 |
| FIGURE 6-10 DETERMINING THE CORNER PULL WITH A PULL FINDER.....                                                                        | 6-11 |
| FIGURE 6-11 BISECTING CORNER PULL WITH PULL FINDER .....                                                                               | 6-12 |
| FIGURE 6-12 BISECTING ANGLE BY TAPE MEASUREMENT .....                                                                                  | 6-13 |
| FIGURE 6-13 ONE HEAD GUY FOR ONE SUSPENSION STRAND.....                                                                                | 6-18 |
| FIGURE 6-14 ONE HEAD GUY FOR TWO SUSPENSION STRANDS.....                                                                               | 6-18 |
| FIGURE 6-15 TWO HEAD GUYS FOR ONE SUSPENSION STRAND.....                                                                               | 6-19 |
| FIGURE 6-16 THREE HEAD GUYS FOR TWO SUSPENSION STRANDS.....                                                                            | 6-19 |
| FIGURE 6-17 CORNER POLE WITH TWO HEAD GUYS.....                                                                                        | 6-21 |
| FIGURE 6-18 CORNER POLE WITH GUYS ON BISECTOR OF ANGLE OF PULL .....                                                                   | 6-21 |
| FIGURE 6-19 RIGHT-ANGLE CORNER MADE ON ONE POLE.....                                                                                   | 6-22 |
| FIGURE 6-20 PIPE INSTALLATION FOR SIDEWALK ANCHOR GUY .....                                                                            | 6-24 |
| FIGURE 6-21 GUY SHIELD INSTALLATION FOR SIDEWALK ANCHOR GUY.....                                                                       | 6-25 |
| FIGURE 6-22 PUSH BRACE CONFIGURATION.....                                                                                              | 6-26 |
| FIGURE 6-23 PUSH BRACE WITH LINE POLE ANCHOR CONFIGURATION .....                                                                       | 6-27 |
| FIGURE 6-24 PUSH AND PULL BRACE, AND DOUBLE POLE BRACE CONFIGURATIONS.....                                                             | 6-28 |
| FIGURE 6-25 H-FIXTURE TYPE .....                                                                                                       | 6-31 |
| FIGURE 7-1 STRAIN INSULATOR - SINGLE LINE TYPE.....                                                                                    | 7-3  |
| FIGURE 7-2 LOCATION OF STRAIN INSULATORS ON POLE-TO-POLE AND ANCHOR GUYS<br>IN EXPOSURE ZONES FOR SUPPLY LINES OF 18 kV OR UNDER ..... | 7-5  |
| FIGURE 7-3 LOCATION OF STRAIN INSULATORS ON POLE-TO-POLE AND ANCHOR GUYS - ZONES ABOVE 18,000 V .....                                  | 7-6  |
| FIGURE 7-4 LOCATION OF STRAIN INSULATORS ON POLES CARRYING TROLLEY FEEDERS.....                                                        | 7-7  |
| FIGURE 7-5 LOCATION OF STRAIN INSULATORS IN ANCHOR GUYS ON JOINTLY USED POLES.....                                                     | 7-8  |
| FIGURE 7-6 STRAIN INSULATOR INSTALLATION WITH TWO 1-BOLT CLAMPS .....                                                                  | 7-9  |
| FIGURE 7-7 STRAIN INSULATOR INSTALLATION WITH TWO 1-BOLT CLAMPS .....                                                                  | 7-9  |
| FIGURE 7-8 STRAIN INSULATOR INSTALLATION WITH TWO 3-BOLT CLAMPS .....                                                                  | 7-10 |
| FIGURE 7-9 STRAIN INSULATOR INSTALLATION WITH FOUR 3-BOLT CLAMPS .....                                                                 | 7-10 |
| FIGURE 7-10 STRAIN INSULATOR INSTALLATION WITH SIX 3-BOLT CLAMPS.....                                                                  | 7-11 |
| FIGURE 7-11 STRAIN INSULATOR INSTALLED IN SERIES USING GUY CONNECTOR .....                                                             | 7-11 |
| FIGURE 7-12 STRAIN INSULATOR INSTALLED IN SERIES USING 3-BOLT CLAMPS .....                                                             | 7-12 |
| FIGURE 8-1 TYPES OF GUY RODS .....                                                                                                     | 8-4  |
| FIGURE 8-2 EXPANDING ANCHOR .....                                                                                                      | 8-5  |
| FIGURE 8-3 PLACING ANCHOR IN ANGLED HOLE.....                                                                                          | 8-7  |
| FIGURE 8-4 PLACING ANCHOR IN VERTICAL HOLE WITH SLOT .....                                                                             | 8-8  |
| FIGURE 8-5 NUT RETAINER ON UNDERSIDE OF EXPANDING ANCHOR.....                                                                          | 8-9  |
| FIGURE 8-6 SINGLE AND TWIN HELIX ANCHORS.....                                                                                          | 8-11 |
| FIGURE 8-7 SCREW ANCHOR WRENCH .....                                                                                                   | 8-12 |
| FIGURE 8-8 TOGGLE-TYPE ANCHOR .....                                                                                                    | 8-15 |
| FIGURE 8-9 TOGGLE ANCHOR MODELS.....                                                                                                   | 8-17 |
| FIGURE 8-10 ADDING AN EYE ON A GUY ROD .....                                                                                           | 8-18 |
| FIGURE 9-1 WRAP-TYPE FALSE DEAD-END.....                                                                                               | 9-2  |
| FIGURE 9-2 WRAP-TYPE FALSE DEAD-END SLACK SPAN .....                                                                                   | 9-3  |
| FIGURE 9-3 WRAP-TYPE FALSE DEAD-END INSTALLED ON SELF-SUPPORTING CABLE .....                                                           | 9-3  |
| FIGURE 9-4 FALSE DEAD-END STRANDWISE.....                                                                                              | 9-4  |

|                                                                                                                                                   |       |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| FIGURE 9-5 FALSE DEAD-END STRANDVISE INSTALLED AT STRAND DIMINISHING POINT .....                                                                  | 9-5   |
| FIGURE 9-6 FALSE DEAD-END USING GUY CLAMP METHOD ON 6.6 M AND 6 M STRAND<br>SUPPORTED BY A CABLE STRAND CONNECTOR .....                           | 9-6   |
| FIGURE 9-7 FALSE DEAD-END USING GUY CLAMP METHOD ON 6.6 M AND 6 M STRAND<br>SUPPORTED BY A POLE STRAND CONNECTOR.....                             | 9-6   |
| FIGURE 9-8 FALSE DEAD-END USING GUY CLAMP METHOD AT ARM LOCATION.....                                                                             | 9-7   |
| FIGURE 9-9 FALSE DEAD-END USING STRANDVISE AND GUY CLAMPS.....                                                                                    | 9-7   |
| FIGURE 9-10 FALSE DEAD-END USING GUY CLAMPS AND STRANDVISE AT CABLE EXTENSION ARM LOCATION.....                                                   | 9-8   |
| FIGURE 9-11 ANCHOR GUY INSTALLED FOR SLACK SPAN CONSTRUCTION .....                                                                                | 9-12  |
| FIGURE 9-12 POLE-TO-POLE GUYS INSTALLED FOR SLACK SPAN CONSTRUCTION .....                                                                         | 9-13  |
| FIGURE 9-13 FALSE DEAD-END AT SLACK SPAN LOCATION (NO CHANGE IN STRAND SIZE).....                                                                 | 9-13  |
| FIGURE 10-1 CONNECTING TO A VERTICAL GROUNDING CONDUCTOR .....                                                                                    | 10-7  |
| FIGURE 10-2 CONNECTING TO A GUY OR STRAND WITH A CABLE-LASHING CLAMP.....                                                                         | 10-8  |
| FIGURE 10-3 CONNECTING TO A GUY OR STRAND WITH A STRAND GROUND CLAMP .....                                                                        | 10-8  |
| FIGURE 10-4 CONNECTING TO JACKETED STRAND.....                                                                                                    | 10-9  |
| FIGURE 10-5 COILED GROUND WIRE TIED FOR LATER CONNECTION .....                                                                                    | 10-10 |
| FIGURE 10-6 DAISY CHAIN CONFIGURATION (NOT RECOMMENDED = .....                                                                                    | 10-11 |
| FIGURE 10-7 BONDING PARALLEL STRANDS.....                                                                                                         | 10-12 |
| FIGURE 10-8 MAINTENANCE STRAND CONTINUITY AT CORNERS.....                                                                                         | 10-13 |
| FIGURE 10-9 BONDING BRANCH STRAND TO MAIN STRAND.....                                                                                             | 10-13 |
| FIGURE 10-10 GUY GROUNDED AT CORNER.....                                                                                                          | 10-14 |
| FIGURE 10-11 GUY GROUNDED AT DEAD-END .....                                                                                                       | 10-15 |
| FIGURE 10-12 GUY GROUNDED AT FALSE DEAD-END .....                                                                                                 | 10-15 |
| FIGURE 10-13 GROUNDING GUY TO SELF-SUPPORTING STRAND .....                                                                                        | 10-16 |
| FIGURE 10-14 GROUNDING GUY WHERE STRANDVISE IS USED ON SELF-SUPPORTING CABLE .....                                                                | 10-17 |
| FIGURE 10-15 GROUNDING GUY THAT IS NOT ELECTRICALLY CONNECTED THROUGH GUY BOLT .....                                                              | 10-18 |
| FIGURE 10-16 BONDING WITH TAIL OF GUY STRAND .....                                                                                                | 10-19 |
| FIGURE 10-17 CONNECTION TO GROUND RODS.....                                                                                                       | 10-20 |
| FIGURE 11-1 IDENTIFICATION MARKER (CABLE TIE) .....                                                                                               | 11-4  |
| FIGURE 11-2 CUSTOM CABLE TAGS .....                                                                                                               | 11-5  |
| FIGURE 11-3 WRAP-AROUND CABLE MARKER.....                                                                                                         | 11-6  |
| FIGURE 12-1 TYPES OF INTERNAL DECAY.....                                                                                                          | 12-11 |
| FIGURE 12-2 TYPES OF EXTERNAL DECAY .....                                                                                                         | 12-12 |
| FIGURE 12-3 A, B, AND C POLE TAGS .....                                                                                                           | 12-20 |
| FIGURE 12-4 POLE BRAND .....                                                                                                                      | 12-21 |
| FIGURE 12-5 EFFECT OF POLE INTEGRITY ON NETWORK RESILIENCY .....                                                                                  | 12-23 |
| FIGURE 12-6 POTENTIAL DECAY PATHWAY IN POLES.....                                                                                                 | 12-24 |
| FIGURE 13-1 ICE STORM LOADING DISTRICTS MAP – FIGURE 250-1 FROM NESC.....                                                                         | 13-4  |
| FIGURE 13-2 STORM LOADS ON CABLE OR CONDUCTORS.....                                                                                               | 13-6  |
| FIGURE 13-3 STORM LOADS IMPOSED ON POLES.....                                                                                                     | 13-6  |
| FIGURE 13-4 GEOMETRY OF OVERLASHED CABLE BUNDLES.....                                                                                             | 13-21 |
| FIGURE 13-5 LOAD ANALYSIS ON GUYED LINE ANGLE POLE.....                                                                                           | 13-26 |
| FIGURE 13-6 LOAD ANALYSIS FOR DEAD END POLE SCENARIO.....                                                                                         | 13-28 |
| FIGURE 14-1 CLEARANCE AND GROUNDING METHODS FOR POWER SUPPLY CABINET -<br>COMMUNICATIONS CABLE AND LICENSEE CABLE ON OPPOSITE SIDES OF POLE ..... | 14-10 |
| FIGURE 14-2 CLEARANCE AND GROUNDING METHODS FOR POWER SUPPLY CABINET -<br>COMMUNICATIONS CABLE AND LICENSEE CABLE ON SAME SIDE OF POLE .....      | 14-11 |
| FIGURE 14-3 POWER SUPPLY LOCATION WHERE SUFFICIENT CLEARANCE ABOVE CABLE IS AVAILABLE.....                                                        | 14-12 |
| FIGURE 14-4 POWER SUPPLY LOCATION SERVING BURIED OR UNDERGROUND CABLE .....                                                                       | 14-13 |
| FIGURE 14-5 CABLE SUPPORT AND CABLE ARRANGEMENT –                                                                                                 |       |

|                                                                                                    |       |
|----------------------------------------------------------------------------------------------------|-------|
| EXPANSION LOOP ON OPPOSITE SIDE OF POLE FROM AMPLIFIER .....                                       | 14-14 |
| FIGURE 14-6 CABLE SUPPORT AND SPACER ARRANGEMENT –                                                 |       |
| EXPANSION LOOP ON SAME SIDE AND BETWEEN POLE AND AMPLIFIER .....                                   | 14-15 |
| FIGURE 15-1 WIRELESS INFRASTRUCTURE (FROM GR-3171) .....                                           | 15-4  |
| FIGURE 15-2 RF HAZARD WARNING SIGN .....                                                           | 15-10 |
| FIGURE 15-3 RF ENERGY ADVISORY SYMBOL.....                                                         | 15-16 |
| FIGURE 15-4 RF SIGNAGE AND DEMARCATION EXAMPLES .....                                              | 15-19 |
| FIGURE 15-5 SPACE ALLOCATION ON UTILITY POLE.....                                                  | 15-23 |
| FIGURE 15-6 POLE TOP ANTENNA ATTACHMENTS .....                                                     | 15-33 |
| FIGURE 15-7 WIRELESS FACILITIES ON LIGHT POLES .....                                               | 15-37 |
| FIGURE 15-8 WIRELESS SELF-STANDING POLE .....                                                      | 15-38 |
| FIGURE 15-9 TYPICAL LOCATIONS FOR WIRELESS ANTENNAS ON JOINT-USE STRUCTURES .....                  | 15-42 |
| FIGURE 15-10 EXAMPLE OF A CROSS ARM ANTENNA ATTACHMENT .....                                       | 15-47 |
| FIGURE 16-1 JOINT USE HANDHOLE (POWER-SUPPLY/COMMUNICATIONS).....                                  | 16-4  |
| FIGURE 17-1 TYPICAL SETUP FOR PURGING LARGE CONVENTIONAL MANHOLES .....                            | 17-9  |
| FIGURE 17-2 TYPICAL SETUP FOR PURGING IRREGULAR-SHAPE MANHOLES .....                               | 17-10 |
| FIGURE 17-3 TYPICAL SETUP FOR PURGING OFFSET-ACCESS MANHOLE WITH NO ENTRANCE MANHOLE.....          | 17-11 |
| FIGURE 17-4 TYPICAL SETUP FOR PURGING OFFSET-ACCESS MANHOLE WITH ENTRANCE MANHOLE .....            | 17-12 |
| FIGURE 17-5 DEEP-NECK MANHOLE VENTILATED BY COUPLING TWO BLOWER HOSES .....                        | 17-14 |
| FIGURE 17-6 DEEP-NECK MANHOLE VENTILATED WITH PERMANENT VENTILATING DUCT INSTALLED IN COLLAR ..... | 17-15 |
| FIGURE 17-7 DEEP-NECK MANHOLE VENTILATED WITH PERMANENT VENTILATING DUCT ADJACENT TO MANHOLE ..... | 17-16 |
| FIGURE 17-8 ALIGNMENT CHART – SIDE 1 COVERING SMALL MANHOLES .....                                 | 17-17 |
| FIGURE 17-9 ALIGNMENT CHART – SIDE 2 COVERING LARGER MANHOLES.....                                 | 17-18 |
| FIGURE 17-10 MANHOLE TESTING, PURGING, AND VENTILATING PROCEDURES – INITIAL TESTS.....             | 17-25 |
| FIGURE 17-11 MANHOLE TESTING, PURGING, AND VENTILATING PROCEDURES – ADDITIONAL TESTS .....         | 17-26 |
| FIGURE 17-12 DECISION TREES IF NO GAS DETECTED .....                                               | 17-27 |
| FIGURE 17-13 DECISION TREES IF GAS DETECTED.....                                                   | 17-27 |
| FIGURE 19-1 CABLE OWNERSHIP.....                                                                   | 19-1  |
| FIGURE 19-2 EXAMPLES OF METAL TAGS.....                                                            | 19-2  |
| FIGURE 19-3 CABLE TAGS.....                                                                        | 19-3  |
| FIGURE 19-4 STRAP-TYPE TAG INSTALLED.....                                                          | 19-4  |
| FIGURE 19-5 ATTACHING CABLE TAG WITH LEAD LASHING WIRE.....                                        | 19-4  |
| FIGURE 20-1 SPLIT-CONDUIT PLUG WRENCH .....                                                        | 20-4  |
| FIGURE 20-2 SPLIT-CONDUIT PLUG REMOVER .....                                                       | 20-5  |
| FIGURE 20-3 SOLID RUBBER CONDUIT PLUGS .....                                                       | 20-7  |
| FIGURE 20-4 SQUARE SPLIT RUBBER CONDUIT PLUGS .....                                                | 20-9  |
| FIGURE 20-5 ROUND SPLIT RUBBER CONDUIT PLUGS.....                                                  | 20-11 |
| FIGURE 20-6 EXAMPLE - TRIPLEX SPLIT PLUG.....                                                      | 20-12 |
| FIGURE 20-7 PLACING SPLIT RUBBER ON CABLE .....                                                    | 20-13 |
| FIGURE 20-8 TIGHTENING PLUG WITH PLUG WRENCH .....                                                 | 20-14 |
| FIGURE 20-9 INSERTING REMOVER SLEEVE.....                                                          | 20-16 |
| FIGURE 20-10 INSERTING EXTRACTOR.....                                                              | 20-17 |
| FIGURE 20-11 ENGAGING RUBBER WITH EXTRACTOR.....                                                   | 20-17 |
| FIGURE 20-12 REMOVING SPLIT RUBBER PLUG.....                                                       | 20-18 |
| FIGURE 20-13 SERVING TAPE USED AS A SPACER.....                                                    | 20-19 |
| FIGURE 20-14 SERVING TAPE INSERTED IN A DUCT .....                                                 | 20-19 |
| FIGURE 20-15 4-INCH UNIVERSAL PLUG.....                                                            | 20-22 |
| FIGURE 20-16 SCHEMATIC OF FOAM DUCT PLUG.....                                                      | 20-23 |
| FIGURE 20-17 EXAMPLE OF FOAM INJECTION STEP.....                                                   | 20-24 |
| FIGURE 21-1 HANDHOLE APPLICATION GUIDE FROM GR-902 .....                                           | 21-20 |



|                                                                                                                                          |       |
|------------------------------------------------------------------------------------------------------------------------------------------|-------|
| FIGURE 21-2 CABLE GUARD .....                                                                                                            | 21-25 |
| FIGURE 21-3 CABLE GUARD INSTALLATIONS .....                                                                                              | 21-27 |
| FIGURE 22-1 SCHEMATIC OF HASB OPERATION.....                                                                                             | 22-3  |
| FIGURE 22-2 TYPICAL CABLE PLACEMENT DISTANCES (SINGLE HASB UNIT) .....                                                                   | 22-4  |
| FIGURE 23-1 SCHEMATIC OF CABLE PULL FOR ILLUSTRATION PURPOSES.....                                                                       | 23-14 |
| FIGURE 23-2 ALIGNMENT CHART FOR CURVED SECTION CALCULATIONS .....                                                                        | 23-15 |
| FIGURE 23-3 PEAK CABLE TENSION VERSUS PULLED DISTANCE - OPTICAL FIBER CABLE .....                                                        | 23-20 |
| FIGURE 23-4 ILLUSTRATION OF MAXIMUM PULLING DISTANCE .....                                                                               | 23-21 |
| FIGURE 24-1 MINI-HDD, INITIAL PILOT HOLE BORING PROCESS.....                                                                             | 24-3  |
| FIGURE 24-2 MINI-HDD, BACKREAMING/PULLBACK PROCESS .....                                                                                 | 24-4  |
| FIGURE 24-3 FACILITY MARKING EXAMPLES .....                                                                                              | 24-13 |
| FIGURE 24-4 PREDICTED MINI-HDD PULL LOAD VS. SAFE PULL TENSION .....                                                                     | 24-15 |
| FIGURE 24-5 MINI-HDD, BORE PATH PROFILE/TRAJECTORY (VERTICAL PLANE) .....                                                                | 24-18 |
| FIGURE 25-1 EXAMPLES OF TERMINOLOGY FOR GROUNDING AND BONDING CONNECTIONS .....                                                          | 25-5  |
| FIGURE 25-2 SELECTION (FLOW CHART) OF APPROVED GROUND .....                                                                              | 25-8  |
| FIGURE 25-3 COMMUNICATIONS DROP WIRE CLEARANCES AND GROUNDING .....                                                                      | 25-17 |
| FIGURE 25-4 NID BOND AND GROUNDING .....                                                                                                 | 25-31 |
| FIGURE 25-5 GROUNDING WIRE .....                                                                                                         | 25-31 |
| FIGURE 25-6 GROUND ROD CLAMPS .....                                                                                                      | 25-32 |
| FIGURE 25-7 GROUNDING WIRE CLAMPS .....                                                                                                  | 25-33 |
| FIGURE 25-8 THREADED METALLIC CONDUIT CLAMPS - STRAP CLAMPS.....                                                                         | 25-33 |
| FIGURE 25-9 METER BOX CLAMPS .....                                                                                                       | 25-34 |
| FIGURE 25-10 TYPICAL GROUND TAGS.....                                                                                                    | 25-34 |
| FIGURE 25-11 NID INSTALLATION .....                                                                                                      | 25-36 |
| FIGURE 25-12 TEST METHOD 1 FOR GROUNDING CONTINUITY CHECK .....                                                                          | 25-37 |
| FIGURE 25-13 TEST METHOD 2 FOR METER BOX CONNECTION .....                                                                                | 25-38 |
| FIGURE 25-14 EXAMPLE 1 - AERIAL SERVICE TO AC POWER DISCONNECT/METER .....                                                               | 25-42 |
| FIGURE 25-15 EXAMPLE 2 - BURIED SERVICE TO AC POWER DISCONNECT/METER.....                                                                | 25-43 |
| FIGURE 25-16 EXAMPLE 3 - AERIAL SERVICE WITHIN 20 FEET OF AC POWER PRIMARY GROUNDING ELECTRODE .....                                     | 25-43 |
| FIGURE 25-17 EXAMPLE 4 - AERIAL SERVICE IN EXCESS OF 20 FEET OF AC POWER PRIMARY GROUNDING ELECTRODE .....                               | 25-44 |
| FIGURE 25-18 EXAMPLE 5 - BURIED SERVICE TO A MOBILE HOME STAKE -<br>POWER SERVICE PRIMARY GROUNDING ELECTRODE WITHIN 20 FEET.....        | 25-44 |
| FIGURE 25-19 EXAMPLE 6 - BURIED SERVICE TO A MOBILE HOME STAKE -<br>POWER SERVICE PRIMARY GROUNDING ELECTRODE IN EXCESS OF 20 FEET ..... | 25-45 |
| FIGURE 27-1 EXAMPLE OF INNERDUCT COUPLINGS .....                                                                                         | 27-10 |
| FIGURE 27-2 PULLING EYE SETUP FOR MULTIPLE INNERDUCT PLACEMENT .....                                                                     | 27-11 |
| FIGURE 27-3 BASKET-TYPE CABLE GRIPS .....                                                                                                | 27-12 |
| FIGURE 27-4 SWIVEL CONNECTOR FOR OPTICAL FIBER CABLE PLACEMENT .....                                                                     | 27-12 |
| FIGURE 27-5 CABLE LUBRICANT AND HAND PUMP .....                                                                                          | 27-13 |
| FIGURE 27-6 INTERMEDIATE MANHOLE CABLE LUBRICATOR.....                                                                                   | 27-14 |
| FIGURE 27-7 FLAT, LINKED AND ILU MICRODUCT PRODUCT ASSEMBLIES.....                                                                       | 27-18 |
| FIGURE 27-8 DIRECT-BURIED AND IN-CONDUIT MICRODUCT CONFIGURATIONS.....                                                                   | 27-19 |
| FIGURE 27-9 MULTIPLE ADSS CABLES ADJACENT TO EXISTING PLANT.....                                                                         | 27-29 |

# List of Tables

|                                                                                                                                                                           |      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| TABLE 2-1 MINIMUM APPROACH DISTANCES (MADs).....                                                                                                                          | 2-9  |
| TABLE 2-2 COMMUNICATIONS WORK RULES AND RISK MITIGATION STRATEGIES.....                                                                                                   | 2-19 |
| TABLE 2-3 MINIMUM DEPTH OF ELECTRIC SUPPLY CABLE .....                                                                                                                    | 2-32 |
| TABLE 2-4 MINIMUM DEPTH OF COMMUNICATIONS PLANT .....                                                                                                                     | 2-32 |
| TABLE 2-5 INSPECTION CHECKLIST .....                                                                                                                                      | 2-38 |
| TABLE 2-6 MAKE-READY SURVEY CHECKLIST .....                                                                                                                               | 2-42 |
| TABLE 3-1 MINIMUM VERTICAL CLEARANCES BETWEEN POWER FACILITIES AND NONCURRENT-<br>CARRYING PARTS OF COMMUNICATIONS FACILITIES ON POLES.....                               | 3-9  |
| TABLE 3-2 VERTICAL CLEARANCE AT SPAN CROSSING BETWEEN SUPPLY AND COMMUNICATIONS CABLES.....                                                                               | 3-14 |
| TABLE 3-3 MINIMUM MID-SPAN AND VERTICAL CLEARANCES (SEE FIGURE 3-8) .....                                                                                                 | 3-16 |
| TABLE 3-4 VERTICAL CLEARANCES FOR COMMUNICATIONS CABLES AND MESSENGERS.....                                                                                               | 3-19 |
| TABLE 3-5 ICE LOADING CONDITIONS .....                                                                                                                                    | 3-21 |
| TABLE 3-6 CLEARANCE FROM SUPPLY LINE CONDUCTORS ON THE SAME STRUCTURE IN ANY DIRECTION<br>FROM COMMUNICATIONS ANTENNAS (0 - 750 V) MOUNTED IN THE POWER SUPPLY SPACE..... | 3-24 |
| TABLE 4-1 STRAND BREAKING STRENGTH.....                                                                                                                                   | 4-2  |
| TABLE 4-2 MAXIMUM STRING TENSION – 4.7 M HS, 6.6 M EHS, AND 6 M STEEL STRAND.....                                                                                         | 4-4  |
| TABLE 4-3 MAXIMUM STRINGING TENSION – 10 M STRAND.....                                                                                                                    | 4-4  |
| TABLE 4-4 MAXIMUM STRINGING TENSION – 16 M STRAND.....                                                                                                                    | 4-5  |
| TABLE 4-5 STRAND SIZE COMPARISON - 6 M VERSUS 6.6 M.....                                                                                                                  | 4-11 |
| TABLE 5-1 MINIMUM BREAKING STRENGTHS.....                                                                                                                                 | 5-20 |
| TABLE 5-2 CHARACTERISTICS OF CABLE-SUSPENSION BOLTS .....                                                                                                                 | 5-21 |
| TABLE 5-3 SUSPENSION STRAND HARDWARE FOR 6.6 M, 6 M, AND 10 M STRAND .....                                                                                                | 5-29 |
| TABLE 5-4 COMBINATIONS OF GUY HOOKS AND SUSPENSION BOLTS FOR TERMINATING GUYS.....                                                                                        | 5-31 |
| TABLE 5-5 HARDWARE FOR TERMINATING STRANDS – LEAD-OVER-HEIGHT RATIO OF 1-1/4 .....                                                                                        | 5-34 |
| TABLE 5-6 HARDWARE FOR TERMINATING STRANDS WHERE THE LEAD-OVER- HEIGHT RATIO IS GREATER THAN 1-1/4 .....                                                                  | 5-35 |
| TABLE 5-7 DIMENSIONS AND TYPES OF GUY CLAMPS .....                                                                                                                        | 5-37 |
| TABLE 5-8 NUMBER AND TYPE OF CLAMPS USED TO TERMINATE GUY STRAND .....                                                                                                    | 5-37 |
| TABLE 5-9 DIMENSIONS AND COLOR MARKINGS OF “B” STRAND GRIPS .....                                                                                                         | 5-39 |
| TABLE 5-10 HARDWARE TYPES AND APPLICATIONS.....                                                                                                                           | 5-50 |
| TABLE 6-1 HEAD GUY STRAND SIZES .....                                                                                                                                     | 6-14 |
| TABLE 6-2 SIDE GUY STRAND SIZES FOR 6.6 M SUSPENSION STRAND .....                                                                                                         | 6-14 |
| TABLE 6-3 SIDE GUY STRAND SIZES FOR 6 M SUSPENSION STRAND .....                                                                                                           | 6-15 |
| TABLE 6-4 SIDE GUY STRAND SIZES FOR 10 M SUSPENSION STRAND .....                                                                                                          | 6-15 |
| TABLE 6-5 SIDE GUY STRAND SIZES FOR 16 M SUSPENSION STRAND .....                                                                                                          | 6-16 |
| TABLE 6-6 GUY STRAND SIZES FOR SIDEWALK ANCHOR GUYS .....                                                                                                                 | 6-17 |
| TABLE 6-7 PIPE SIZES FOR SIDEWALK ANCHOR GUYS .....                                                                                                                       | 6-22 |
| TABLE 6-8 PUSH GUYS BRACE AND LINE POLE ANCHOR.....                                                                                                                       | 6-28 |
| TABLE 6-9 MAXIMUM ALLOWABLE PULL ON H-FIXTURE AT CORNER [1].....                                                                                                          | 6-32 |
| TABLE 7-1 STRAIN INSULATOR CHARACTERISTICS .....                                                                                                                          | 7-2  |
| TABLE 7-2 GUY STRAIN INSULATOR LOCATIONS.....                                                                                                                             | 7-6  |
| TABLE 7-3 STRAND LOOP SIZES .....                                                                                                                                         | 7-12 |
| TABLE 8-1 UNMARKED GUY RODS (USED WITH EXPANDING ANCHORS).....                                                                                                            | 8-4  |
| TABLE 8-2 SIZES OF ANCHORS, GUY RODS, AND ASSOCIATED GUY STRANDS.....                                                                                                     | 8-6  |
| TABLE 8-3 ANCHOR PLACEMENT MEASUREMENTS (FOR FIGURE 8-4).....                                                                                                             | 8-9  |
| TABLE 8-4 SCREW ANCHORS .....                                                                                                                                             | 8-13 |
| TABLE 8-5 SOIL CLASS DEFINITIONS .....                                                                                                                                    | 8-14 |
| TABLE 8-6 TOGGLE ANCHOR GUYING SYSTEMS .....                                                                                                                              | 8-16 |
| TABLE 9-1 FALSE DEAD-END FOR GALVANIZED STEEL STRAND .....                                                                                                                | 9-2  |

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|--------------------------------------------------------------------------------------------------------|-------|
| TABLE 9-2 OPTIONAL STRINGING TENSIONS FOR SLACK SPANS .....                                            | 9-9   |
| TABLE 9-3 APPROXIMATE SLACK SPAN SAGS AND TENSIONS FOR 100-FOOT SPANS AT 60°F (17°C) .....             | 9-11  |
| TABLE 12-1 EXAMPLES OF WOOD SPECIES BY SAPWOOD THICKNESS .....                                         | 12-7  |
| TABLE 12-2 POLES WITH HOLLOW HEARTS .....                                                              | 12-13 |
| TABLE 12-3 POLES WITH ENCLOSED POCKETS .....                                                           | 12-14 |
| TABLE 12-4 POLES WITH EXPOSED POCKETS .....                                                            | 12-16 |
| TABLE 12-5 INSPECTION SELECTION AND FREQUENCY GUIDELINES .....                                         | 12-27 |
| TABLE 13-1 WOOD POLE CLASSIFICATION SYSTEM .....                                                       | 13-3  |
| TABLE 13-2 NESC 2023 EDITION - ICE STORM LOADING DISTRICTS PER RULE 250B (TABLE 250-1) .....           | 13-5  |
| TABLE 13-3 EXAMPLES OF NESC LOAD FACTORS - PER NESC TABLE 253-1 .....                                  | 13-9  |
| TABLE 13-4 CONSTRUCTION GRADES FOR COMMUNICATIONS LINES (SEE NOTE 4) .....                             | 13-11 |
| TABLE 13-5 DEPTH OF SETTING POLE .....                                                                 | 13-14 |
| TABLE 13-6 REMAINING POLE MARGIN – UNGUYED TANGENT LINES .....                                         | 13-23 |
| TABLE 13-7 REMAINING POLE MARGIN – GUYED POLES AT LINE ANGLES .....                                    | 13-27 |
| TABLE 13-8 STRENGTH FACTORS FOR STRUCTURES - DERIVED FROM NESC TABLE 261-1 .....                       | 13-30 |
| TABLE 14-1 LINE-POWERING VOLTAGES RANGES .....                                                         | 14-4  |
| TABLE 15-1 FCC LIMITS FOR MAXIMUM PERMISSIBLE (MPE) EXPOSURE FOR PUBLIC AND OCCUPATIONAL WORKERS ..... | 15-8  |
| TABLE 15-2 ANTENNA PLACEMENT CONSIDERATIONS ON EXISTING JOINT-USE POLES .....                          | 15-43 |
| TABLE 20-1 SOLID RUBBER CONDUIT PLUGS – DIMENSIONS .....                                               | 20-7  |
| TABLE 20-2 SQUARE SPLIT RUBBER CONDUIT PLUGS – DIMENSIONS .....                                        | 20-8  |
| TABLE 20-3 ROUND SPLIT RUBBER CONDUIT PLUGS – DIMENSIONS .....                                         | 20-9  |
| TABLE 21-1 CABLE DEPTH - RANDOM SEPARATION OF COMMUNICATIONS CABLES [NOTE 1] .....                     | 21-3  |
| TABLE 21-2 TRENCH DEPTH .....                                                                          | 21-4  |
| TABLE 21-3 CONDUIT/INNERDUCT SELECTION GUIDE .....                                                     | 21-11 |
| TABLE 21-4 CONDUIT/INNERDUCT - MINIMUM WORKING PULLING STRENGTH (*) .....                              | 21-11 |
| TABLE 21-5 U CABLE GUARDS, STRAPS, AND MATERIAL REQUIRED FOR INSTALLING U CABLE GUARDS .....           | 21-26 |
| TABLE 21-6 CAST IRON CAPS, G PLASTIC CAPS, U CABLE GUARD SIZES, AND CABLE DIAMETERS .....              | 21-26 |
| TABLE 22-1 MINIMUM RECOMMENDED AIR COMPRESSOR SIZE .....                                               | 22-7  |
| TABLE 23-1 DESIGN COEFFICIENTS OF FRICTION .....                                                       | 23-13 |
| TABLE 23-2 KEY PARAMETERS FOR TENSION CALCULATIONS .....                                               | 23-14 |
| TABLE 23-3 TENSION CALCULATION FOR ILLUSTRATED PULL CASE IN FIGURE 23-1 .....                          | 23-16 |
| TABLE 24-1 APWA UNIFORM COLOR CODE .....                                                               | 24-12 |
| TABLE 25-1 MADE ELECTRODE – GROUND RESISTANCE COMPARISON .....                                         | 25-21 |
| TABLE 26-1 SELECTED CALIFORNIA GENERAL ORDERS .....                                                    | 26-19 |
| TABLE 26-2 GO 95 VERTICAL CLEARANCES FOR CABLES ABOVE GROUND .....                                     | 26-20 |
| TABLE 26-3 GO 95 VERTICAL AND HORIZONTAL CLEARANCES FOR COMMUNICATIONS CABLES .....                    | 26-21 |
| TABLE 26-4 GO 95 VERTICAL CLEARANCES FOR COMMUNICATIONS CABLES NOT SUPPORTED ON THE SAME POLE .....    | 26-22 |
| TABLE 26-5 GO 95 CLEARANCES FOR COMMUNICATIONS CABLES FROM SIGNS .....                                 | 26-22 |
| TABLE 26-6 GO 95 OTHER HORIZONTAL CLEARANCES .....                                                     | 26-22 |
| TABLE 26-7 GO 128 CLEARANCES .....                                                                     | 26-23 |
| TABLE 27-1 PMD GUIDELINES .....                                                                        | 27-3  |
| TABLE 27-2 SUMMARY OF UNDERGROUND TOOLS FOR OPTICAL FIBER CABLE PLACEMENT .....                        | 27-8  |
| TABLE 27-3 INNERDUCT UTILIZATION .....                                                                 | 27-11 |

# 1 General

This Special Report (SR) describes uniform construction procedures to be followed by all parties authorized by the communications company to place their communications facilities on supporting structures or in trenches owned, administered, or provided by the communications company. This manual includes the basic considerations and requirements relative to the construction practices and procedures that may apply in a communications company's operating area.

The construction methods, materials, and tools covered in this manual are intended to minimize the possibility of creating conditions that

- Are hazardous to the general public and to any personnel working on, in, or around supporting structures
- Could impair service or the restoration of service to customers of all parties using the supporting structures.

Not only is the demand high for wireless services to support 5G/6G and anywhere-at-anytime communications services, but also the passage of the *Infrastructure Investment Act (2021)* with components such as *Broadband Equity, Access and Deployment* (BEAD) creates the opportunity for expanding Outside Plant (OSP) construction over the next decade.

The application of uniform design and construction practices as presented in this *Blue Book* will help make this construction process more efficient, enhance worker safety and result in a more reliable and resilient network.

## 1.1 Scope and Purpose

*SR-1421, Blue Book - Manual of Construction Procedures*, provides guidance and a set of recommended practices that promote reliable network performance and comply with applicable national codes, are consistent with current Occupational Safety and Health Act (OSHA) rules, and seek to meet the best industry practices. This *Blue Book* provides a sound basis for developing productive Joint-Use Agreements (JUAs) and collaboration with other utilities such as power supply companies.

The *Blue Book* is not a compliance document. There are many OSHA rules, Environmental Protection Agency (EPA) regulations, Department of Transportation (DOT) requirements, and other agencies that can affect the operations of a communications company that are not directly covered in the *Blue Book*, although cross references, when appropriate, are present. These auxiliary issues are properly addressed in specific work rules issued by individual companies. The focus of the *Blue Book* is on the best design principles and construction practices for communications networks.

## 1.2 Safety, Design, Reliability and Resiliency

The current demands on communications networks require both reliable and resilient networks to meet economic objectives of wireline and wireless service providers to provide the broadband Internet of Things (IoT) service demands of users. These demands have increased because of the ubiquitous nature of broadband and wireless communications, coupled with the umbrella concern of national preparedness in the case of natural disasters and from the more malicious actions that concern the Department of Homeland Security (DHS).

**“Resiliency”** is somewhat different than “reliability” and relates to the ability of a system to withstand, with minimum degradation, exposure to severe events (natural or human-caused) and to recover rapidly to its full functionality. Resilience can be achieved through various strategies, including (a) avoidance of service loss despite the failure of a single component using duplicate routes, (b) additional backup power (stored battery energy or diesel generator), and/or (c) rapid restoration of service through forward planning or even by detecting preliminary signs of failure and actively dispatching service/repair technicians prior to service loss so as to minimize time (and cost) to repair. There are also operational measures of how fast a service is restored to full operation, as well as more flexibility criteria associated with community resilience that employs alternative services (e.g., joint-use agreements with competitive communications providers).

The concept of resilience recognizes that the many utilities that support a community, including those listed below, are deeply interdependent:

- Power
- Communications
- Gas - alternative power sources for backup and portable engines
- Transportation - fuel supplies
- Water – supply feeds, drains and sewer
- Steam pipes.

Among these utilities, none are more intimately interconnected and interdependent as power and communications; each requires the other and relies on their backup strategies.

The term “reliability” implies the degree of confidence with which a service or facility will continue to function and provide its intended service, typically under normally encountered events or anticipated exposures. For example, reliability may be measured by the number and/or duration of service outages of the network.

Reliability has been, and will continue to be, maintained through construction of weather- and environmental-resistant facilities with component parts that meet stringent functional performance requirements.

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The philosophy of maximum reliability is to take reliable support hardware, cables, equipment, and other tested parts, and interconnect them to form networks with no weak links and minimize the single points of failure.

There are several inter-related elements to achieve these reliability and resiliency goals, including:

1. **Safety** – The safety guidelines discussed in this *Blue Book* are based on the National Electrical Safety Code (NESC), National Electrical Code (NEC), and a long history of the Bell System experience.
2. **Design and Engineering Choices** – The national safety codes such as NESC and NEC provide a “de facto minimum” set of baseline principles that are added to by the design and engineering departments of utilities using their experience and knowledge of the products and applications. One does not design to minimum safety standards, but good designs start from and seriously take into consideration the baseline guidance provided by such codes.
3. **Generic Requirements (GRs)** – Ericsson - NIS and the communications industry have developed a variety of functional performance specifications to help increase the reliability of the thousands of individual component products that make up any network. Some cross-references to relevant Generic Requirements documents (GRs) and industry standards were added to Issues 6 and 7 of the *Blue Book*.
4. **Construction and Installation Practices** – This *Blue Book* contains high-level guidelines on the best practices for creating a safe and reliable network.
5. **Operation and Maintenance** – The clearances, separations, and working spaces defined by the NESC rules and the guidelines in this *Blue Book* help create joint-use, Right-of-Ways and easement environments that are safe for the public and utility workers, and for facilities adjacent to those being actively worked on.

The NESC is the national safety code of choice to help ensure the safety of workers and the public during the operation, maintenance, and repair of power supply and communications facilities located between the point of generation and the customer service point. Calling these safety objectives “design” or “de facto minimum design” can be misleading since “design” is usually so strongly associated with engineering, planning, and building activities. Furthermore, the present stated purpose of the NESC explicitly excludes any deliberate attempts to include “design” information to any significant degree. However, these safety objectives of the NESC and of this *Blue Book* can be considered to cover operation, maintenance, and repair activities for communications lines and facilities, including:

- A. Working around, near, or in the vicinity of power supply lines and facilities
- B. Minimum clearances and separations for network safety and reliability

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- Between components of network facilities (e.g., distances between conductors and hardware of one network)
  - From other network facilities (e.g., separations between communications and supply facilities).
- C. Operational robustness (or resilience) under expected and reasonably anticipated environmental conditions that include abnormal events associated with
- Weather stresses such as ice, wind, rain, flood, hurricane, and so forth
  - Lightning events
  - Power fault or cross
  - Excavation damage.

The safety codes (NESC and NEC) and these construction guidelines are not strictly design standards, but they do play a critical role with the other elements noted above in contributing to the reliability and resilience of communications networks.

See Appendix C for further discussion on resiliency, reliability and the interdependence between communications and power utilities and networks.

### 1.3 Interdependence of Communications and Power Utility Plant

Communications and power utilities are intimately interconnected and interdependent as each requires the other and relies on their backup strategies to keep the power on and the communications possible under all expected and emergency situations.

Both communications and power companies employ overlay or backup facilities to help ensure maximum reliability for the networks.

Communications has power backup in form of batteries and diesel generators to bridge service demands during power supply disruptions. Similarly, power companies have established supplementary communication systems of wireless, radio, and fiber facilities in case of a problem with their primary internal communications service. Despite these backup reserve facilities, both telecom and power assume that extended disruption or loss of the telecom and utility power services is a low probability event.

The coupling between communications (telecom) and electric utility (power) companies becomes evident as the responses of the telecom network and power grid to various disaster scenarios are considered. The telecom company depends on power company to “keep the juice flowing”, while the power company relies on the telecommunications technologies and industry to keep their internal communications, monitoring and control circuits (e.g., Supervisory Control And Data Acquisition - SCADA) running during disturbances and disruptions.

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In the construction of the traditional telephone wireline networks, there was mutual agreement and contractual cooperation between communications and power companies to help each other meet and exceed the high reliability targets set for both networks. In the competitive broadband world, there are challenges to maintain the high reliability while:

- (i) Meeting the increasing demands for instant connectivity for the complete range of telecommunications services, and
- (ii) Being prepared for the natural and man-made disasters that will occur (both expected and unexpected).

Improved cooperation between communications and power utilities is a necessary requirement for the future if the high levels of network reliability and service availability are to be maintained.

In general, communications companies make provision for up to 72 hours of backup power (stored energy in power plant and diesel for generators) at CO locations. A key component of the powering scheme is backup power are Remote Terminal (RT) sites. These RT sites or nodes are defined for this document as sites where active equipment is deployed outside the CO facilities in CEVs, huts, cabinets and closures. For these nodes, the following backup power practices are typically used:

- Minimum reserve of at least 4 hours of battery backup is standard for Remote Terminals (RTs).
- Most (>90%) RT sites of large wireline providers are designed with 8 hours of backup power.
- Many remote terminals sites of larger providers have external hookups points for additional power or portable generators (gasoline, natural gas or propane powered).
- A small number (<5%) of critical RT sites have gasoline/natural gas engines built into the cabinet/hut design.

**Note:** Typical functional performance requirements for powering communications systems can be found in GR-513-CORE, *Power Requirements in Telecommunications Plant (LSSGR Section 13)* Issue 2, 2010.

As a result of these provisions for backup power in the telecommunication's networks, the effect on communications services (wireless and wireline) of a power outage is not significant until the power outage becomes long or widespread. For such major power outages, the ability to deploy mobile generators to remote site (including cell sites) and the ability to deliver fuel to required locations will determine how long the telecommunications networks continue to supply essential telephony service. Essential service in this context usually includes medical, emergency-911 and alarm monitoring services.

Emerging broadband architectures (e.g., Verizon's FiOS, AT&T's U-Verse, G-



Fast reverse powering) are more vulnerable to power loss at the customer premises during long-term outages. Communications services for power facilities (e.g., those used for SCADA systems) are well protected against power outages, power faults, lighting and operational disturbances that occur along generation-transmission-distribution supply networks.

To maintain telecom services during long outages (>24 hours) or indefinitely would require large capital outlay with small chance of a rapid return on the capital investment. From field trials and equipment performance during actual power outages, various lessons can be, and have been, learned to help maximize reserve power and to reduce network power dependence of telecommunications service.

The general recommendations to maintain communications service during power outages and disturbances are provided below in terms of both physical infrastructure suggestions and operational protocol strategies.

**Physical Infrastructure:**

- Deploy increased battery storage and/or generation capacity at customer premises and at remote terminal locations.
- Deploy new storage technologies to increase power reserve capacity – e.g., UPS, higher capacity battery technologies (lithium-ion batteries).
- Develop and field test emergency plans that include rapid deployment of portable generators to critical service nodes at remote terminals in the outside plant. Full field simulations to evaluate emergency response plans and procedures should be scheduled at least every two (2) years. These simulations shall include building blackout testing during extreme summer and winter temperature conditions, regardless of the tenants. Such a full building blackout test is designed to ensure that:
  - All necessary building AC loads are on the generator's standby bus
  - The generator is properly sized for the building
  - The generator's "life support" systems (e.g., fuel pumps, oil cooler pumps, water pumps, start battery charger, etc.) are powered from the generator they are serving
  - These parameters are measured during periods of peak demand, and/or worst ambient environmental conditions
  - Critical office facilities and communications systems are powered from the generator
  - The office emergency lighting system is working properly.
- Conserve energy use to maximize reserve time of available power, through using more energy efficient equipment and/or improved operational protocols to reduce operational power use.

- Use network and route diversity to circumvent damage zone and supply telecommunications circuits and services through an alternate pathway:
  - Maintain dual cables, paths, and operational facilities
  - Use duplicate networks – microwave, copper, fiber, cellular, etc.
- Power Generation Diversity – implement new alternate energy systems (e.g., fuel-cell systems, wind systems, solar panels, etc.) to make power supply for telecommunications independent of the AC power grid.

The above strategies are focused on the physical and technical measures that can be used to help the infrastructure better deliver telecommunications. There are also various operational strategies that can greatly improve the reliability and availability of telecommunications networks and services including the following suggestions.

**Operational Protocols:**

- Complete full-scale test of emergency procedures for networks and facilities
- Full tests of backup systems to determine the effectiveness of power backup capacity and efficiency of secondary and dual-power delivery systems
- Implementation of plans for rapid deployment of portable batteries and generators to remote sites to supplement reserve power.

Tests of these emergency plans are important not only to evaluate the logistics of the plan but also to evaluate the human factors critical to the successful implementation of these emergency plans. The ability of telecom and electric utility workers to get the job done requires the ability to get the correct information to the right person, at the right time.

Another more complex human factor to an emergency plan's success is the education of the public, business and governmental customers of these telecommunications services. Expansion of the public education program covers

- (i) What can be expected to happen to their telecommunications services during power outage, and
- (ii) What personal actions they can possibly take to maintain telecommunications service as long as possible during the power outage.

The psychology, public policy and politics of emergency notification and public education programs are outside the scope of this report.

Whatever approach is used to attain the necessary or desired levels of

reliability, resilience and service availability there will be a need to

- Develop an economic analyses to determine the reasonable return of investment and total lifetime costs for the technical measures and compare these costs with a quantitative measure (cost) of the potential service disruptions and outages that can result from the various disaster and emergency scenarios.
- Complete full-scale tests of operational effectiveness under disaster conditions and emergency responses and evaluate the actual performance of current networks relative to their as-designed responses and the Network Reliability and Interoperability Council (NRIC) Best Practices and industry guidelines (i.e., a gap analysis).
- Provide technological assessments of the best new alternate power technologies to supplement or replace AC power grid supply.
- Define and evaluate various recovery and restoration plans that can provide rapid response to massive incidents (e.g., Richter scale 9.5 earthquake or denotation of nuclear device) that require extensive rebuilding of communications networks. These plans may involve extensive deployment of mobile cell tower sites for rapid re-establishment of telecom services and links to the rest of the country and the world. In these events with large scale and widespread destruction of property and infrastructure, the temporary recovery and restoration plans may be very different from traditional telecom services (e.g., satellite-based systems) and also different from the best solutions for the long-term rebuilding of the communications network.

See Appendix C for further discussions on resiliency, reliability and the necessary interdependence between power and communications networks.

## 1.4 Coordination Between Codes, Standards, and Other Agreements

Ericsson - NIS helps ensure that this Blue Book is in harmony with industry's best practices and the most recent national codes, Federal Communications Commission (FCC) rules, and OSHA regulations through our active participation in the technical subcommittees (SCs) of the NESC and the Code-Making Panels (CMPs) of the NEC.

Further input to this guidance document is provided by field data and experience from clients, coupled with Ericsson - NIS participation in ANSI-certified industry standards bodies under the auspices of such organizations as ATIS, ANSI-O5, AWP, ASTM, and IEEE.

**Note:** American National Standards Institute (ANSI); Alliance for Telecommunications Industry Solutions (ATIS); ANSI-O5 committee that develops ANSI O5 standards for wood poles and crossarms; American Wood Protection Association (AWPA); American Society for Testing and

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Materials (ASTM); and Institute of Electrical and Electronics Engineers (IEEE).

This *Blue Book* is designed to be used in conjunction with formal Joint-Use Contracts and Rights-of-Way (ROW) Agreements (see Chapter 26) between communications providers and supply utilities, and other joint users of their facilities. The practices and configurations described in this *Blue Book* are often cited directly or are included by general inference into such contracts and agreements between the communications provider and other companies with whom they share facilities. The *Blue Book* is also used by communications companies as part of their contractual agreement when construction, installation, or maintenance work on the network needs to be sub-contracted out to other companies.

As poles and underground conduit space become more congested (crowded) with competing service providers, utilities, municipalities, and other interested stakeholders, the value of the pole space and the cost of pole attachments will become a significant business factor. The appropriate clearances, separation, and engineering safety factors described in this *Blue Book* will be an important element to help define appropriate and acceptable joint-use configurations to help ensure that communications and supply workers remain safe and that the utility networks remain highly reliable into the future.

The equipment and hardware described herein are also assumed to have been designed and manufactured to meet appropriate functional performance requirements using Quality Management Systems (QMSs) that meet TL/ISO 9000 or equivalent criteria. The use of comprehensive product specifications helps ensure that a reliable communications network is constructed.

It is also assumed that all construction activities and equipment installation work is accomplished by properly trained and supervised workers following industry's best practices.

When the above combination of documents, standards, and guidance documents, along with best practices, are combined effectively, the system of checks and balances will help ensure that a highly reliable physical infrastructure is available to support the best possible current and future broadband communications network.

In addition to NESC rules that provide minimum requirements for much of the USA, local variations can be applied such as in California and some other western states of the USA instead of the NESC. These California General Orders (GOs) are issued by the California Public Utilities Commission (CPUC) as regulatory requirements and include:

- GO 95 - *Overhead electric line construction*
- GO 128 - *Construction of underground electric supply and communication systems.*

Although there are many similarities, key differences in clearances and separations between the NESC and GO 95/128 will be identified within relevant sections of the *Blue Book*.

Such local variations and additional requirements may be found in regulatory documents, or internal company design criteria with objectives to include additional safety factors for higher reliability, added resiliency, or provide additional space for workers during normal maintenance activities on joint use structures.

Local variations and engineering adjustments will often be needed if the construction crew and installation workers find through the on-site evaluation that the immediate conditions do not match the engineering plans or the existing environment (e.g., precise pole position, soil condition, wood decay) or other mitigating circumstances are not as assumed. Through effective training of crews along with calls for engineering help, the on-site team can often meet the safety and operational objectives of the construction/installation work assignment.

See Section 26.4 for further discussions about GO 95 and GO 128 and the minimum clearances within those General Orders.

## 1.5 SR-1421 History

The *Blue Book - Manual of Construction Procedures* was first published in the early 1990s to help facilitate joint-use (power and communications) deployments in aerial and underground plant applications that were safe for workers, and to help create reliable networks that were able to be efficiently operated, maintained, and repaired. The 1990s experienced an expansion of power and communications network building as a result of deployments of new fiber and other broadband services, and the growth of new competitive communications providers (CLECs). The *Blue Book* has been revised numerous times, usually in response to a new NESC issue as well as when changes in construction methods and new practices have been developed for the fiber and wireless networks.

This Issue 7 of SR-1421 replaces Issue 6 (March 2017). Previous issues of the *Blue Book* were released in 1990, 1993, 1998, 2004, 2007, 2012 and 2017 and followed the releases of new NESC code issues.

In addition to the usual updates to NESC/NEC code references and the inclusion of answers to user's questions received between 2012 and 2017, the sixth edition released in 2017 included:

- A new wireless-focused Chapter 15 in response to the expansion of **wireless** technologies, facilities, and applications, with a focus on safety concerns for the public and other workers who may be on joint-use structures.
- Expanded coverage of the more recent deployment aspects of **optical fiber cable and associated facilities** (in Chapter 27).
- Expanded discussions on the **grounding and bonding** practices needed for wider deployments of wireless facilities and optical fiber cables to various network nodes (FTTx) included primarily in

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Chapters 10 and 25 so as to help enable effective and coordinated electrical protection for network components.

## 1.6 Blue Book - Issue 7

The changes in this new Issue 7 continue those efforts begun in Issue 6 to expand discussion and guidance on the expanding network aspects around wireless facilities, grounding & bonding practices, and new powering architectures. In particular, this Issue 7 includes:

- Content revised to harmonize with the latest changes in the **2023 issues of NESC and NEC codes**, and to include expanded commentaries and details where necessary. Changes have been made throughout the *Blue Book* to address and harmonize with these latest code releases as well as to align with anticipated changes for future code cycles as much as practical.
- Chapter 15 covering **wireless technologies**, facilities, and applications, is updated to reflect latest developments in small cell wireless applications, expanded 5G/6G deployments, and new powering architectures for these wireless facilities (Chapters 14 and 15).
- Sag and tension guidance information for **slack span construction and overlashing** of cables was added in Chapter 4 and 9 (Section 9.6) that are important to support deployment of wireless facilities.
- Chapter 14 on **supply circuits and equipment** has been expanded to include the latest powering architectures particularly being required to meet the powering demand for the expanding deployment of wireless facilities. Discussions on the new **Fault Managed Power Systems (FMPS)** were reviewed in Chapters 2 (Section 2.2.1) and 14.
- New material on the general features of **Joint-Use Agreements (JUA)** and recommendations around the best practices for use of these JUA documents to help to make construction, installation and maintenance operations more efficient and effective were included in Chapter 26. The contents of Chapter 26 in Issue 6 on vertical risers and cable guards have been relocated to the more appropriate Chapter 21 (Sections 21.9 and 21.10).
- The revised Chapter 26 also contains clearance information of the **California General Orders 95 and 128** as they pertain to aerial and buried plants.
- Updates and revisions have been made to elaborate on **grounding and bonding practices** as well as **powering architectures** that have been required to meet the wider deployments of wireless facilities (antennas and associated powering and control devices) and optical fiber cables to various network nodes (FTTx) - see Chapters 10, 14 and 25. Modern devices, components, and facilities routinely have power and communications capacities integrated in a single device; this requires



appropriate practices of grounding, inter-system bonding, and electrical surge/fault protection to be harmonized as well as to help protect the public, workers and equipment.

- Updated guidance on appropriate and the preferred **grounding means** (specific rods and alternate connections) was added to Chapters 10 and 25.
- The commentaries and guidance on **pole inspection and rehabilitation** in Chapter 12, as well as expanded guidance sections on **loading and strength factors** in Chapter 13. Further more detailed commentaries are provided in Chapter 13 and Appendices A and B on use of the latest wind and ice maps in the NESC.
- Information on **pole braces** and **H-fixtures** was added Chapter 6.
- Expanded discussions on the relationship between **reliability, resiliency and design choices** for telecommunications networks were included in Chapter 1 and Appendix C. New commentaries on the **interdependence of communications and power networks** were added to Chapter 1 (Section 1.6) and in Appendix C with detailed information on design choices, operational procedures and industry best practices to enhance service reliability and availability.
- Calculation scenarios are provided for **pulling tensions** in buried plant installations in conduits/ducts including specific examples for optical fiber cables in Chapters 23 and 27 (see Section 23.8).

The preceding bullet list of items identifies the major areas of change. Various changes throughout the *Blue Book* have been made to address minor NESC and NEC changes, product advancements, added comments to other code (e.g., GO 95) activity of interest, and to provide operational guidance on equipment, product, or network choices. Many useful practical changes were made in response to questions, enquiries and code interpretation requests received from Ericsson - NIS clients and *Blue Book* users.

## 1.7 Company Terminology

The terms *communications company* or *telecommunications service provider* are used for the primary communications utility that owns, administers, or provides the physical facilities for the communications networks. Such owned and administered facilities can include directly owned and jointly owned poles, underground structures, manholes, conduit system trench systems, and rights-of-way. To maintain continuity with earlier issues, this *Blue Book* may include older terminology such as “communications (telephone) company”. To maintain continuity with NESC terminology, “*communications*” will be used over the more generic term “*telecommunications*.”

***Licensees*** – Other communications companies or utilities that attach to poles and have Joint-Use Contracts and/or Licensee Agreements, will be referred to as *users*, *licensees*, or otherwise referenced as appropriate for the discussion. Other licensees and attachees may include:

- Investor-owned entities
- Municipality/governmental agencies – for traffic monitoring and control, street/ outdoor lighting, irrigation systems, and other purposes or services that provide benefits to multiple customers
- Cable Television (CATV) service providers
- Companies providing wireless communications services.

These utilities/licensees provide services that benefit multiple customers and may include purposes such as traffic monitoring and control, street/outdoor lighting, irrigation systems, and other purposes or services.

***Supply Company*** – The terms *electric company*, *electric supply company*, and *power utility company* are used to refer to the utility company or entity that generates and distributes primary electric power in the area.

***Joint-Use*** – The term Joint-Use refers to the situation where a structure or excavation trench along a Right-of-Way is shared by several utilities or licensees noted above. The list of joint users includes traditional electrical utilities, incumbent communication utilities, municipality-owned networks as well as competitive wireline, wireless and optical fiber based communications and CATV network providers.

## 1.8 Blue Book Structure

The *Blue Book* consists of the following 28 chapters and 5 appendices, grouped in terms of aerial, underground, and buried application environments, as well as by transmission medium (fiber, wireless) and other related subjects:

### General Chapters

- **Chapter 1** – The general scope and purpose of the *Blue Book*, including a global discussion of the factors that contribute to making a reliable network and providing resilient services with additional details on these issues placed in the Appendices A, B and C.
- **Chapter 2** – General safety precautions and summary guidelines, with cross-references to other chapters and sections in the *Blue Book* where more detailed discussions can be found.



## Aerial Plant

- [Chapter 3](#) – Clearances for communications lines, equipment, and facilities above the ground and away from nearby structures, as well as separation from other joint-use facilities.
- [Chapter 4](#) – Strand and support messengers, with discussions on appropriate sizing, material selection, stringing tensions and guidance on slack spans.
- [Chapter 5](#) – Pole line hardware, with broad ranging discussion of proper use and selection of pole mounting and attachment hardware for supporting lines and equipment on wooden and non-wooden poles.
- [Chapter 6](#) – Guys, braces and support wires are covered with discussion on the proper size and selection of guys for given pole configurations in situations such as corners, dead-ends, small/large pull, and sidewalk anchor guys.
- [Chapter 7](#) – Insulated guys covering the appropriate sizing and locations for insulators to help ensure the safety of the public and workers.
- [Chapter 8](#) – Anchors and guys, explaining the differences between the various anchor/guy combinations for different soil types.
- [Chapter 9](#) – Suspension strand, giving the appropriate use of suspension strand arrangements for situations requiring false dead-end strandwise and slack span configurations.
- [Chapter 10](#) – Grounding and bonding for aerial plant, showing the various and preferred bonding and grounding connections required in aerial plant to secure effectively bonded and grounding plant.
- [Chapter 11](#) – Marking of aerial wireline and wireless plant (cables, guys and facilities) to help the ready identification of joint-use facilities for the mutual safety of all workers on the structure.
- [Chapter 12](#) – Pole testing and inspection, including the physical methods for ensuring pole safety prior to climbing or accessing plant on the pole, quantitative measurements of pole decay (e.g., strength remaining), and recommendations on preferred testing frequencies.
- [Chapter 13](#) – Pole strength and loading, including a high-level discussion on design strength and loading considerations, depth of set, and reliability factors for poles (wooden and non-wood) to meet applicable code and regulatory requirements.
- [Chapter 14](#) – Pole locations and configurations for supply equipment, amplifiers, and other powering sources mounted on joint-use poles and includes guidance on new powering architectures for wireless facilities.

## Wireless Facilities

- [Chapter 15](#) – A revised chapter that discusses the appropriate placement, work practices, and Radio Frequency (RF) safety programs

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appropriate for wireless antennas and facilities for maintaining adequate working space and climbing space and minimizing RF exposure of workers in the vicinity.

### Underground Facilities

- [Chapter 16](#) – General precautions and work rules for manholes detailing how work activities in these confined spaces require due care and attention to help keep the public and worker safe.
- [Chapter 17](#) – Procedures for the testing of manhole atmospheres and applying ventilation requirements to help ensure that the confined space is free of dangerous gases and that sufficient purging occurs to minimize hazards and risks and prevent injury.
- [Chapter 18](#) – Bonding and grounding for underground plant in manholes.
- [Chapter 19](#) – Permanent cable tags and other markings for underground plant to help the ready identification of underground facilities.
- [Chapter 20](#) – Products and procedures used for the sealing of conduits, ducts, ductliners, and microducts to help maintain the seal integrity of the cable paths and to help protect the cable and splice products.

### Buried Facilities

- [Chapter 21](#) – General construction specifications and choices for direct-buried plant including separations, required depths, and bonding/grounding requirements, along with recommended procedures for excavations, backfilling, and ground restoration methods. This chapter also covers the transition plant from underground/buried plant to aerial plant using vertical cable risers up poles and the protection required for these transition points that was moved from Chapter 26.
- [Chapter 22](#) – Installation practices and design considerations for High-Air-Speed, Blown Cable (HASB) techniques for cable placement. These include operation principles, equipment descriptions, site preparation, and set-up reviews for this cable placement method.
- [Chapter 23](#) – A review of the procedural and safety guidelines for direct-buried innerduct construction using plowing, trenching, and microtrenching methods. Examples are provided for the calculation of pulling tensions under general conditions as well as specific scenarios with optical fiber cables deployment.
- [Chapter 24](#) – Directional drilling chapter exploring the necessary preliminary site inspections and investigations (surface/sub-surface), along with safety considerations that include pre-work activities of location, marking, bore-path selection and layout, coupled with guidance on implementation aspects such as tracking, location, reaming, and pulling operations.

- **Chapter 25** – Bonding and grounding for drop service cables and their connections to the customer at Network Interface Devices (NIDs), Building Entrance Terminals (BETs), Intersystem Bonding Terminations (IBTs), and other well-defined service demarcation points. This chapter includes detailed discussions on the NESC and NEC requirements and their objectives for effective grounding and bonding for electrical safety at the customer location.
- Chapter 26 – Joint-Use agreements and a commentary on clearances used in the California General Orders 95 and 128 . This chapter covers the basic principles of the Joint-Use Agreement (JUA) and recommendations for best practices for their use to help make network operations more efficient and effective.

### Optical Fiber Facilities

- **Chapter 27** – Various construction, safety, and design choices particularly associated with Fiber-To-The-X, where “X” can denote many different network nodes or customer demarcation locations [e.g., Controlled Environmental Vault (CEV), cabinet, hut, handhole, NID, BET, or home gateway device]. This chapter covers fiber cable deployment in all plant environments (aerial, buried, and underground) with a focus on the particular safety aspects, design, and construction-related practices that are distinctive for the optic fiber technology.

### Other Related Subjects and Appendices

- **Chapter 28** – Symbols for grid, mapping, and plat drawings. Provides general guidance on symbols used in technical plans and drawings [e.g., Computer- Aided Design (CAD), Graphic and Interactive Design (GID)] to help promote the use of a uniform, consistent set of symbols across the communications industry.
- **Appendix A** – Discussion on the latest wind and ice loading maps used in the NESC along with current open issues and concerns with pole strength and loading rules.
- **Appendix B** – NESC Code update, which contains a summary of the code issues that are currently active and are expected to lead to code changes or revisions in the next code cycles (i.e., 2028 for NESC).
- **Appendix C** – Discussions on communications network resiliency and reliability perspectives as well as a commentary on the interdependence between power and communications networks with references to NRIC (Network Reliability and Interoperability Council) best practices. The appendix discusses past history and current operational procedures, design choices, and the industry work rules.
- **Appendix D** – A listing of the documents referenced in this *Blue Book*. This overall reference appendix is supplemented by separate, new reference sections provided at the end of many of the chapters. Those

sections include cross-references to other industry practices and standards, as well as to product generic requirements pertinent to outside plant products.

- [Appendix E](#) – Definitions of the acronyms used in this *Blue Book*.

## 2 General Safety Precautions and Guidelines

This chapter covers the general safety precautions to be observed when working on poles, cables, guys, wire, strand, joint-use and jointly owned structures, pole-mounted aerial equipment, and underground and buried plant.

This chapter is intended to be a reference guide for the safe performance of work operations; it supplements the referenced chapters on clearances, separations, safety, and specific work operations in this guidance manual.

All personnel must conform to the federal, state, and local laws requiring Personal Protection Equipment (PPE) to be worn when performing particular work operations. Examples of PPE include hard hats, safety glasses or goggles, insulating gloves, proper footwear, and work gloves.

Construction, maintenance, and repair work of the communications plant involves potentially dangerous situations because the work is often performed

- In aerial lifts, bucket trucks, buried trenches, and confined spaces
- In the vicinity of high-voltage and high-current power supply cables and apparatus
- With heavy equipment and structures, including utility poles, excavators, and large cable reels
- Using significant mechanical forces, particularly during strand and guy tensioning, cable deployment, cabinet placement, and pole setting operations.

It is the responsibility of management and construction personnel to be cognizant of hazardous work areas and conditions, and to abide by the appropriate methods and practices to limit, as much as reasonably possible, the risks associated with working in the communications plant environment.

### 2.1 Working in the Vicinity of Power Conductors

While working in the vicinity of power conductors, know what voltages are involved. Do not assume the voltage of any power source and be equally aware of the lower secondary voltages that can also be dangerous and lethal. Plan and take the necessary steps to do the work operation safely.

Detailed plans, work orders, or drawings that involve joint-use plant or non-joint power crossing plant must show the voltage involved, clearances required, and any known hazardous condition that may be encountered during the work operation. If the specified clearances on the work order, or the minimum clearances as shown in the clearance section, cannot be met, notify your supervisor or the appropriate engineer.

The prevention of contacts between communications plant and power conductors, and maintaining the required clearances, are the responsibility of each employee. It is the prime concern of both supervisors and employees when

working on joint-use poles, on power crossings, or in the vicinity of power conductors.

Ground the communications wire, cable strand, etc., during placing, rearranging, removal, and tensioning operations. To be effective, the ground connection should be a bond made to a low impedance ground such as the vertical ground conductor of a common neutral power system or in-place cable and strand, etc. This additional protection in no way modifies or makes unnecessary the safety precautions outlined in this chapter or chapters on specific work operations.

**Note:** The term “effectively grounded” is used throughout the NESC and may be understood differently across the communications and supply industries. Within this Blue Book, the term “grounded” is used and shall mean a bonding connection to a supply neutral conductor or, more often, to a grounded system [driven rod, Multi-Grounded Neutral (MGN), etc.] designed to minimize hazard to personnel and having sufficiently low resistance and/or impedance to ground (earth) to permit prompt operation of circuit protective devices. The bonding and/or grounding conductor shall be large enough to carry possible available fault currents. When used in the Blue Book, the term “grounded” shall be interpreted to meet the usual definition of “effectively grounded” that normally equates to 4 grounds in every mile.

When connecting to the Multi-Grounded Neutral (MGN) or making a bond connection in the space above communications attachments, never approach closer than 40 inches below the power supply space. Test the vertical power guy or ground wire of an MGN as outlined in [Chapter 10](#) before connections are made.

### 2.1.1 Job Plan or Job Briefing

NESC Rule 421(A)(6) harmonizes with OSHA regulations and contains a “Job Briefing” requirement for the first-level supervisor to

*“.....Conduct a job briefing with the employees involved before beginning each job. A job briefing should include at least the following items: work procedures, personal protective equipment requirements, energy source controls, hazards associated with the job, and special precautions ”*

Since many, if not most, tasks in communications work are accomplished by a single technician working alone, the safety of the worker is accomplished through prior training and employer oversight. To meet this NESC Rule 421(A)(6) and equivalent OSHA rules, each employee working alone must have adequate time and resources to plan the tasks to be performed and do his or her job safely. To the extent that the supervisor participates in the work by assigning a job to an employee, that supervisor must conduct a job briefing. This type of briefing may, out of necessity, be general and may not address hazards unique to the work site. Of course, once the employee arrives at the work site, job planning to cover specific work-site hazards must be conducted.

In the case of emergency work, storm damage, broken poles, downed wire, etc., do not start work operations until the utility supply company has cleared away, restored, or made safe (see Section 2.1.2 below) all power conditions on the pole and in the vicinity. This must be confirmed by a responsible employee of the utility supply company. The employee will usually have appropriate emergency contact information for the power utility, gas company, fire, and police, or be able to coordinate such needs through their operations center (manager, dispatcher, etc.).

Insulating gloves and sleeve protectors must be worn by all persons handling poles, cable, wire, strand, guys, and associated equipment during placement, removal, tensioning, tying, grounding, etc., in the vicinity of power conductors. In addition, avoid all contact of exposed, unprotected parts of the body with any reel, wire, pole, motor vehicle, etc., during periods when there is a possibility of power contact.

Under no condition is it permissible to get closer than the Minimum Approach Distance (MAD) to energized exposed power conductors with any part of the body or with any non-insulated tool, pole, basket platform, etc., as listed in [Table 2-1](#), unless the conductors have been de-energized and grounded, or the employee or equipment is insulated from the conductor.

### 2.1.2 Made-Safe (or Make-Safe)

The phrase “made-safe” or “*make-safe*” as used in the *Blue Book* and in the Outside Plant (OSP) industry is a term that generally refers to a plant condition that is made safe through temporary means. There may be various types and reasons for unsafe plant conditions, but most fall under one of the following categories:

- Emergency storm damage where broken poles, downed wires and cables, or similar circumstances have created the potential to expose the public and workers to AC grid power voltages and currents.
- A plant condition or defect where a structure, facility, or apparatus is deemed unsafe because it does not meet the minimum safety requirements owing to environmental conditions, age, or deterioration of components; an impact from a vehicle; or other sources which could include vandalism or non-compliance with standard methods and procedures.

Regardless of the cause of the unsafe plant condition, immediate action is required to ensure the safety of the general public, utility workers, and other workers in the area. In addition, temporary corrective action will also help avoid further plant damage and possible service disruptions. A permanent fix is the ultimate solution in all cases. However, a quick and full restoration of the damaged plant is not always possible because of the environmental conditions that exist at the time and/or the need for specific material supplies such as poles, cable, closures, and other types of apparatus. Therefore, the most efficient or expeditious solution is often a temporary fix in which the



plant is made-safe until the permanent solution is achievable at a more appropriate time.

### **Emergency Restoration After Storm Damage**

Storm damage can wreak havoc with plant and in many cases affect power companies, CATV and telecommunications plant alike. When this happens, all the affected utilities need to assess the damaged plant and coordinate their recovery operations.

As a general safety precaution and work rule, the power company should restore or clear damaged electric lines and equipment first before other utilities are allowed to restore their plant. This step is essential to avoid electrical injury to non-power company workers and to avoid possible damage to telecom plant and equipment. There are times, however, when utility teams (power, telecommunications and CATV) need to work together to clear the way, or work in conjunction with placing structures such as poles. In those circumstances, a work zone needs to be made-safe for all workers.

Corrective action is required prior to any work being performed if the electrical supply plant is in contact with the ground, or with the communications plant, or within the separation, clearance or MAD, as described in [Section 2.1.3](#). Before restoration of communications equipment can begin, either the power plant has to be placed back to its original safe operating condition or be deemed and certified as made-safe by a responsible power company person. In this situation, the term “make-safe” can mean that the electric plant is de-energized or cut dead (i.e., power source off).

As the initial safety measure, it is of utmost importance that all telecommunications workers first verify with their electrical test-sets that there is, in fact, no electric source on the telecommunications plant. Once the telecom plant has been determined to be free of foreign electrical current, restoration work may proceed. As an extra safety precaution, the telecom worker should perform all restoration work tasks wearing insulating gloves. The technician also needs to be aware of possible exposure to voltages/currents derived from local back-up generators that may be activated during power blackouts.

The following general rule applies when working in a storm damage area or where power lines are down:

**General Rule:** Do not attempt to restore or remove communications plant until the electric plant and facilities have been removed, replaced back to their original safe condition, and power restored.

**Caveat:** In the case of urgent need, communications repair work could proceed before full restoration of power facilities, providing that (a) the following four steps (A-B-C-D) are all followed, and (b) full approval and agreement is obtained from the supervisor of the communications worker; i.e., the responsible communications company person (see definition of responsible person below).



- A. Do not attempt to clear or restore communications plant until a responsible power company person declares that power has been cut dead in the work zone.
- B. Once step A has been carried out, the telecommunications worker must still verify that there is no electric current existing on the telecommunications plant from other power sources such as local backup generators that may back-feed voltage/current into the power conductors. This is accomplished by checking with their voltage tester or electric test set.
- C. After verifying that the telecom plant is free of foreign voltage, the telecommunications employee should work with insulating gloves as an extra safety precaution unless the difficulty of completing detailed work operations using such thick insulating gloves creates the potential for additional work hazards.
- D. Continued and regular communications throughout the restoration process with the power company personnel is important to help ensure proper safety procedures are in place and that workers are notified before electric power is put back in service.

If any doubt exists about the information received on the energized state of the power facilities in the area, or if approval is not given by the worker's supervisor, then the General Rule applies.

Properly installed local backup generators and distributed power systems should include safety circuits to prevent such back-feeding of voltage/current in the case of a power grid blackout. However, the conservative practices and approach described above using insulating gloves and voltage test units shall help ensure the safety of the communications technician.

### **Unsafe Plant Condition or Defect**

The second condition described that requires corrective action for the plant to be "made-safe" addresses multiple situations where a plant condition exists such that a structure or apparatus is deemed unsafe because it does not meet the minimum safety requirement as a result of:

- Aged, decayed, or deteriorated plant
- Physical damage caused by vandalism, an impact from a vehicle, or other cause
- Installation not in compliance with best practices or applicable code (e.g., NESC) because of facility changes by other utilities or incorrect procedures being used
- Environmental conditions.

Examples of such plant conditions that could require attention to be made-safe include the following:

- Bottom of pole (from around the ground line to butt) is deemed structurally unsafe because of insect damage, defective or decayed wood, age-related wear and degradation.
- Structural damage to a pole due to vehicle or other impacts
- Broken guy wire or lashing wire
- Downed cables, slack cables, low-hanging cables or drop wires
- Broken pedestal, cabinet, terminal, or otherwise damaged hardware.

In all these cases, the severity of these abnormal conditions is subject to a qualified person's judgment along with the level of restoration that needs to be taken, and to the timeliness of the permanent fix that needs to be made. Some conditions require an immediate permanent fix, but many conditions can be made-safe by temporary measures such as (a) propping up or supporting a pole with reinforcement such as securing the pole with wood cross-arms or metal bars, (b) lashing a damaged pole to an existing sound pole, or (c) re-tying and securing of the lashing wire. Each case needs to be addressed separately to determine the severity of the problem and what the immediate solution is to make the abnormal condition safe.

Each case would also have its own timetable before a permanent fix is required. It may be hours, days or weeks, but that determination should be made by a responsible communications person. The main purpose in making the plant safe is to address the abnormal plant condition in the most timely, effective and efficient manner. It is not always possible to provide a timely permanent solution due to many factors, as discussed. However, it is critical to attend to these conditions in a prudent manner to avoid injury and/or damage. All abnormal conditions must be assessed and the appropriate fixes made to avoid unwanted circumstances for the safety of all.

**Responsible Persons** – In the above considerations and discussions, the identification of the “responsible power company person” and the appropriate “responsible communications person” needs to be clearly identified to all concerned. The identity of these individuals should be established and documented in joint-use agreements and cooperative work agreements between the affected utility companies. The individuals may vary between different cases and scenarios, but as a baseline guidance one should define them as follows:

- **Responsible power company person** = supervisor for the affected plant or area. This is the person that is the immediate supervisor of the qualified power company technician who is responsible for the repair work in a storm restoration or emergency recovery situation. For example, this individual would be the person who has the responsibility of riding out the pole line prior to the re-energizing of the power line to ensure that all the public and workers (power and communications technicians) are clear of the lines and hazard. It is not the technician or an apprentice technician. It should not be the local police or fire personnel since they do not have the qualification

and training.

- **Responsible communications company person** = workcenter supervisor for the affected plant or area. This is the person that is the immediate supervisor of the qualified communications technician who is responsible for the repair or maintenance work in a storm restoration or emergency recovery situation. It is not the repair technician or cable installation technician.

For the circumstances where the problem is very localized (a single downed pole or a fault with a power drop at a single residence), the judgment of the qualified communications worker and the qualified power employee (technician) is sufficient to ascertain the safety status of the situation and the necessary requirements for making a work site safe. A site is “very localized” when the single worker can clearly see all relevant activities and equipment from their normal work site. It is not considered localized if restoration activity on a power facility is around a corner or far way.

In general, it is necessary that the supervisory level manager bear the responsibility for having a work site “made-safe”. The requirement is particularly important during power restoration activities during emergency recovery work when it is imperative that clear, precise, rapid communications and coordination exist between the supervisors of the different utilities and between the supervisors and their line workers.

When a corrective action is needed for a plant condition such as stabilizing a damaged or decayed pole, the communications technician has the training and skills to safely execute the corrective action when working alone or only with an apprentice (helper). For these work activities, it is assumed that normal work practices such as testing for voltages, staying outside MADs, and other standard operating procedures are applicable and being followed. Therefore, there are no abnormal hazards associated with accidental electrical contact or close approach to energized parts.

In such circumstances, the power utility should not need to be alerted since it is purely a communications facility issue. However, the communications technician/ worker should report and possibly obtain approval from the “responsible communications company person” defined above to proceed with the “make-safe” corrective action. Such reporting activity helps the supervisor ascertain if the extent of such conditions or defects warrants a systematic proactive remedial action plan.

**Electrically safe work condition vs make safe** – The definition of *Electrically Safe Work Condition* found in NFPA 70E® (*Standard for Electrical Safety in the Workplace*) is

*“A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested for the absence of voltage, and, if necessary, temporarily grounded for personnel protection.”*

where the defined safe work condition created has all electrical conductors or

circuit parts in a de-energized state to eliminate any possibility of any electrical hazards. Such an approach is not practical or appropriate for communications circuits.

The design of communications networks are such that work can safely proceed on energized communications circuits. Compliance with functional requirements such as found in GR-1089, GR-513, and GR-3108 as well as industry consensus ATIS standards coupled with compliance with safety codes (OSHA, UL60950, NESC and NEC) creates a safe working condition for communications worker carrying out normal installation, maintenance and repair work on communications networks.

Furthermore, the clearance and minimum approach distance requirements found in applicable safety codes (NESC or GO 95) and industry best practices between the communications lines and the electric utility power lines, helps to create a safe work zone around the communication space on joint use supporting structures and underground plant.

### 2.1.3 Minimum Approach Distances (MADs)

The MAD values in Section 431 of the NESC (2023 Edition) and in [Table 2-1](#) were based on the latest IEEE 516 (IEEE Guide for Maintenance Methods on Energized Power Lines) calculations, with 1 foot added for inadvertent movement of a worker and an additional 1 foot added as a communications worker safety factor. The MAD distances apply not only to the employee, but also to the edge of the bucket/lift device and hand tools being used. For [Table 2-1](#) and the more detailed tables in NESC Rule 431, the number of voltage ranges were expanded to better match transmission and distribution supply line listings. As with all safety rules, these MAD values are minimum default values, and a worker should maintain as large a separation as reasonably possible from any energized lines and equipment.

**Table 2-1 Minimum Approach Distances (MADs)**

| <b>Voltage<sup>(1)</sup><br/>Phase to Phase</b> | <b>Minimum Approach Distances<sup>(2)</sup></b> |               |
|-------------------------------------------------|-------------------------------------------------|---------------|
|                                                 | <b>(ft-in)</b>                                  | <b>(m)</b>    |
| 300 V and less                                  | Avoid Contact                                   | Avoid Contact |
| 301 V to 750 V                                  | 1-1                                             | 0.33          |
| 751 V to 15 kV                                  | 2-3                                             | 0.69          |
| 15.1 kV to 36 kV                                | 3-0                                             | 0.91          |
| 36.1 kV to 46 kV                                | 3-6                                             | 1.07          |
| 46.1 kV to 72.5 kV                              | 4-0                                             | 1.22          |
| 72.6 kV to 121 kV                               | 4-9                                             | 1.43          |
| 121.1 kV to 145 kV                              | 5-4                                             | 1.60          |
| 145.1 kV to 169 kV                              | 5-10                                            | 1.78          |
| 169.1 kV to 242 kV                              | 7-8                                             | 2.30          |
| 242.1 kV to 362 kV                              | 12-3                                            | 3.70          |
| 362.1 kV to 420 kV                              | 14-11                                           | 4.55          |
| 420.1 kV to 550 kV                              | 17-8                                            | 5.38          |
| 550.1 kV to 800 kV                              | 23-8                                            | 7.19          |

**Table Notes:**

- (1) Telecommunications workers should seldom be in the vicinity of supply lines with phase-to-phase voltages in excess of 72.5 kV. The MAD values for higher voltage situations in [Table 2-1](#) are provided for completeness and for possible use if work on wireless communications equipment on pole/tower structures is undertaken. In such examples (towers), it would be better if rigid fixed barriers as noted in NESC Rule 432 are employed to help ensure communications workers are always outside of the applicable MAD distances.
- (2) The MAD values in [Table 2-1](#) are applicable from sea level to 3000 feet altitude. At higher voltages (>72 kV), significant increases in MAD values are required at higher altitudes (i.e., in mountainous areas). For example, near a 250 kV line, the MAD value for a communications worker increases from 12 feet-3 inches at sea level to 13 feet-2 inches (16% increase) for locations at 3,001 to 6000 feet altitudes, and to 15 feet-8 inches at altitudes above 6,000 feet (28% increase). For specific MAD values applicable at higher altitudes for phase-to-phase voltages above 72.5kV, the reader should refer to the complete NESC Rule 431 and its tables.

The [Table 2-1](#) footnotes reference increases in MAD values applicable for facilities located in high altitudes (mountain areas). In general,

communications plant should not be placed under transmission supply lines with voltage above 69 kV, unless protection is provided through having an umbrella of lower voltage distribution lines between the high-voltage transmission line and the communications lines.

It is essential for the safety of communications employees, the general public, and communications plant that the required clearances be maintained as outlined in [Chapter 3](#) of this document.

### 2.1.4 Use of Rope

Never use any pull lines, control lines, etc., other than ropes in good condition that are dry and free of metallic strand, or its equivalent, of sufficient size and strength for the particular work operation in the vicinity of power conductors. The traditional rope for communications workers has been the manila rope, which is made from the leaves of the abacá plant and is durable, flexible, and resistant to saltwater damage, allowing its use in rope, hawsers, ships' lines, and fishing nets. Manila ropes shrink when they become wet. This effect can be advantageous under certain circumstances, but if it is not a wanted feature, it should be well taken into account. Since shrinkage is more pronounced the first time the rope becomes wet, new rope is usually immersed into water and put to dry before use so that the shrinkage is less than it would be if the rope had never been wet. A major disadvantage in this shrinkage is that many knots made with manila rope became harder and more difficult to untie when wet, thus becoming the subject of increased stress.

The modern synthetic ropes made of various plastic materials are equivalent in performance and handling characteristics to the traditional manila rope. The synthetic ropes are less affected by water and can be used instead of manila ropes. Any ropes used should meet the applicable criteria of ASTM F-1701, *Standard Specification for Unused Rope with Special Electrical Properties*, or an equivalent industry standard. Some other acceptable ropes can include:

- Nylon ropes that offer high tensile strength, high elasticity, energy absorption and impact resistance properties.
- Polyester ropes that offer high tensile strength, low elastic elongation, high melting point and good abrasion resistance.
- Multi-filament polyolefin (polypropylene or polyethylene) ropes that can be soft and make flexible ropes with a tactile feel similar to nylon. They are lightweight fibers that have good buoyancy (floats), which can be an advantage for some applications.

These synthetic ropes (particularly the polyolefin ropes) may not age as well in sunlight as the manila rope and may need Ultraviolet (UV) stabilizers and/or carbon black additives to make them durable.

Wet or damp rope shall not be used around high voltage wires except in an emergency and then only when the workers are protected by rubber gloves.

The strength of rope may be reduced through:

- Over-stressing - Repeated uses under ordinary tensions, overloading of rope, and stresses applied very quickly.
- Internal friction of rope internal fibers - Through working ropes over sheaves that are too small or around objects that are too small. Similar damage can also occur if inappropriate choices of knots, bends, hitches, splices, coiling/uncoiling and lashing practices are not followed.
- External wear - Resulting from dragging ropes or rough or sharp surfaces.
- Contamination by mud, sand and grit - The small sharp particles can work between rope fibers and grind/break them. If contaminated, let the rope dry and then whip it up and down on a flat smooth surface such as a paved road to remove embedded soil/dirt.
- Chemicals - The leakage of acidic and alkaline agents from storage batteries can degrade rope fibers.
- Water Exposure - The strength of the rope is resistant to water exposure providing the rope is promptly dried and stored properly. Prolonged exposure to water and dampness can initiate mildew and rot. The rope should be cleaned and dried as soon as practical after exposure and stored (hung) on brackets provided on trucks - kept off the floor and away from sharp objects.
- Sunlight Exposure (UV) - Older ropes that are used and stored outside need to be regularly examined to help ensure UV damage has not compromised the rope strength. The synthetic ropes in particular can be susceptible.

Like all PPE (Personal Protection Equipment), ropes should be inspected regularly and before each use for evidence of mildew, rot, broken fibers and changes in color. Never use a rope that is in a doubtful condition.

**Note:** Descriptions of the proper use and maintenance of ropes is found in a manufacturer's rope guides or in Bell System Practice 081-510-101, *Manila Rope - Description and Use*.

## 2.2 Identifying Power

In most cases, clearance, approach distances, and safety protection from power conductors are determined by the voltage involved and the type of construction used by the power company. Conductors of the same size and construction may be carrying very different voltages and require different clearances and safety measures appropriate to the situation based on the operational conditions and choices by the power utility. The voltage on the conductors varies depending on the particular system of connections and grounding used by the power company.

The type of construction must be considered for clearance purposes. Open

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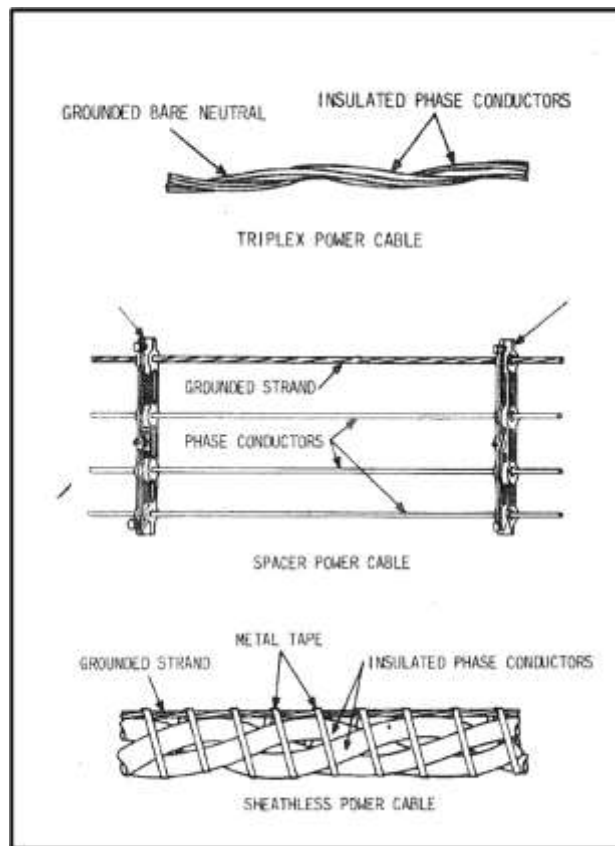
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insulated conductors always require maximum clearance for voltage involved. Clearance from spacer cable and sheathless cable is determined by the voltage; whereas with sheathed cable, voltage is not a factor. [Figure 2-1](#) shows various common examples of power conductors.

The voltage involved in joint-use and power-crossing poles is difficult to determine accurately in the field.

**Note:** Power construction and equipment vary between areas and utilities. If you do not know or cannot accurately determine the voltages, contact your supervisor, the engineering forces, or the local utility company before proceeding with the work operation.

**Figure 2-1 Various Types of Power Conductors**



Transmission lines can vary depending on supply network but would usually be at voltages of 72 kV or 121 kV and higher. Transmission lines are typically on dedicated structures (towers) with no joint-use with communications lines.

Distribution lines can be at 15 kV to 72 kV voltages with the lower voltage distribution lines (e.g., 15 kV to 34.5 kV) found on joint-use poles of 35 to 50 feet in height with some 69 kV lines occasionally present. The higher distribution voltages (35 kV to 73 kV) are more usually found on smaller



towers and high poles (> 60 feet), and only occasionally are on joint-use structures with communications lines.

Supply facilities to commercial and industrial customers can range between 7.5 kV and 15 kV services with the utility plant usually on poles and where communications plant can often be found in joint use on these poles.

Power supplied to customers will normally be less than 15 kV with service drops of 120/208 V (residential) and 277/480 V (business/commercial).

### 2.2.1 Powering of Communications Equipment and Smart Grid Devices

As the demand for powering remote devices grows to include smart grid devices, wireless facilities and other new IoT technologies, the wider use of span-powering and line-powering architectures along with Power-over-Ethernet and other customer-powered configurations has increased.

Communications networks have a long successful history of using line-powering over their twisted-pair conductors for various tasks, such as T-1 repeater powering, High-bit-rate Digital Subscriber Line (HDSL) remote unit powering, and Fiber-To-The-Curb (FTTC) powering. Line-powering remains popular for existing and emerging technologies because it does not require expanded placement of power company meters, rectifiers, and batteries at remote locations. Even though power is dissipated ( $I^2R$  losses) in the transmission of line power, it is still often more cost-effective for the relatively small wattage needs compared to placing AC power and associated power-conditioning equipment at the remote end.

The safety and best practices for working on these line-powering circuits are guided by GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*, and industry documents, including ATIS-0600030, that are based on power limitations and voltages less than 200 Vdc with respect to ground (e.g., nominal -48 Vdc, -130, -190,  $\pm 130$ ,  $\pm 145$ ,  $\pm 190$ ). Line-powering voltages are either positively ground-referenced, or bipolar center-tap ground-referenced (e.g.,  $\pm 130$ ,  $\pm 145$ ,  $\pm 190$  Vdc). Negative voltage on the energized conductor(s) helps limit corrosion (versus a negative ground-referenced system) of the copper pairs if water or moisture intrusion occurs into the OSP cables or splices.

The more relevant functional performance and safety documents from the communications industry that complement GR-1089 include the following.

- ATIS-0600030 - *Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops*
- ATIS 0600337 - *Requirements for Maximum Voltage, Current, and Power Levels Used in Communications Circuits*
- ATIS 0600315 - *Voltage Levels for DC-Powered Equipment Used in*

*the Telecommunications Environment*

- ATIS 0600316 - *Electrical Protection of Telecommunications Outside Plant*
- ATIS 0600338 - *Electrical Coordination of Primary and Secondary Surge Protection for Use in Telecommunications Circuits*
- ITU-T K.50, *Safe Limits of Operating Voltages and Currents for Telecommunications Systems*.
- UL/CSA 60950-1, *Information Technology Equipment – Safety – General Requirements*.
- UL/CSA 60950-21, *Information Technology Equipment – Safety – Remote Power Feeding*.
- IEC 60479, *Effects of Current on Human Beings and Livestock*, Part 1 (*General Aspects*) and Part 2 (*Special Aspects*).

It is generally agreed that below 60 Vdc (classified as extra low voltage) will have little effect on a body (unless the skin is wet or has open wounds). The line voltages noted above do reach into the area of 60-150 V that may produce currents that result in a mild shock and muscle paralysis; and even into the bottom portion of the 150- 300 V range that may produce currents that result in severe burns and ventricular fibrillation. In general, the power levels (voltage x current) do not pose a threat to communications workers who need to work on these lines if normal precautions and best practices are followed. Personnel working on, or around, line-powered systems shall be properly trained to work on such systems and shall follow these basic safety precautions:

- Do not work on exposed plant during a thunderstorm.
- When work operations require activities such as opening a cable shield, place temporary bonds as appropriate to minimize potential differences caused by a temporarily discontinuous path to ground.
- Whenever possible, work on only one conductor of a pair at a time; this helps prevent contact with the higher voltage between two conductors in a line- powering or span powering system.
- Use hand tools with insulated handles.
- Keep the area of the skin in contact with a conductor as small and as dry as possible since the resistance of the skin is directly proportional to the area of skin contact.
- Avoid simultaneously contacting a grounded object with part of your body while handling bare conductors (dry footwear will provide some insulation from ground).

**Fault Managed Power Systems** - To accommodate the increased demand for enhanced wireless (5G/6G) communications services, a large number of wireless antenna and associated equipment are being added to networks. The use of existing joint-use utility poles will be the likely location for these installation along with other possible sites such as lighting poles (streetlights), buildings, roofs and so forth. All these wireless facilities will require power for their operation and various configurations are being designed and trialed including not only those circuits noted above incorporated inside twisted pair and hybrid (fiber/twisted pair) communications cables, but also newer circuitry schemes such as Fault Managed Power Systems (FMPS).

These FMPS systems deliver pulsed power with software systems to detect faults or problem conditions in the DC powering circuit and automatically, and rapidly (within 10 milliseconds), de-energize the powering circuits. The control system for these FMPS systems are analogous to a GFCI circuit inside a house.

The safety and best practices for FMPS circuits are also guided by GR-1089, and the various industry documents listed above. However, in addition specific new standards were developed to ensure the reliability and safety of these new powering schemes -

- ATIS Technical Report 600040 - *Fault Managed Power Distribution Technologies - Human Contact Fault Analysis* provides description of FMPS and testing protocols based on IEC 60479-1 and IEC-60479-2 with a subtending document, ATIS-0600040.01 *Fault Managed Power Systems – Interlock Equipment Barriers for Limiting Access to Energized Conductors and Terminals via Contact Preclusion*.
- UL (Underwriters Laboratory) - UL 1400-1 *Outline of Investigation for Fault-Managed Power Systems - Part 1: General Requirements* which contains Listing requirements and testing protocols for FMPS equipment
- UL 1400-2 *Outline of Investigation for Fault-Managed Power Systems - Part 2: Requirements for CL4 Cables for use with Class 4 (FMPS) equipment* were developed with a scope covering indoor cables with outside plant cables covered as CL4-O or CL4-OSP type cables.
- NFPA 70 (NEC) – Two new Articles (722 and 726) introduced in the 2023 NEC for Fault Managed Power Circuits, Systems and associated cabling.

One objective of these industry standards is to help ensure that whichever powering system is developed for communications equipment, the trained communications worker can safely install, maintain and repair equipment by following the same industry best practices and procedures that have been successful for so long.

**Other Future Powering Schemes** – As the demands for more power and more wired and wireless communications services increase, other innovative powering technologies are being developed and deployed in field trials. One such example was previewed in the IEEE Spectrum magazine (June 2022) entitled “*Spooky Powering at a Distance*” describing a prototype system of laser powering of a wireless site through the air. Any new scheme needs to follow a similar path as the FMPS system meeting the functional performance, safety and industry best practices milestones to ensure a safe and effective powering scheme.

In the development of such new powering schemes, the safety of the public and workers will be a paramount concern that needs to be addressed within the considered process of safety codes (e.g., NESC, GO 95, OSHA, ANSI), consensus industry performance standards and best practices development through organizations such as GRs, ATIS documents and UL standards.

### 2.2.2 Electric Safety of Communications Circuits - Arc Flash and Electric Shock

NESC Rule 410A3 applies to both electrical and communications workers and requires that a risk assessment be performed to assess the potential that an arc-flash hazard exists in the work environment of a communications employee during their normal operational activities.

**Note:** Guidance on arc flash risk assessment, appropriate PPE and labeling can be found in the various references including NESC (Rule 410A3), OSHA 1910.269/268, National Fire Protection Association (NFPA) 70E, and NEC (Marking and Arc-Flash Warning sections of Article 110 in the 2023 edition). Although each document has a different approach, the intent and requirements of these resources are generally in harmony with one another.

Based on qualitative and quantitative arc-flash risk assessments coupled with review of best work practices and engineering control options, communications employees in their normal work positions and environments do not require specific Fire-Retardant (FR) protective clothing to complete their tasks safely.

The engineering design of communications networks coupled with routine work controls and best practices employed during communications activities help to minimize arc-flash risks and contact hazards with electrical power lines and equipment.

### 2.2.2.1 Telecommunications Circuits are Inherently Safe

Telephone, Internet, and/or video services provided by communications companies are conveyed to customer premises largely through electrical signals transmitted over thin copper wires or coaxial cable, or by light signals transmitted over glass fiber-optic strands, (collectively referred to here as “communications *circuits*”, as distinguished from other electrical circuits, such as those providing traditional 110V-AC electrical power to a customer premises). The electrical signals sent through these copper-based communications circuits that would be at a customer premises and in the local loop also have no potential to cause injury through electric shock, burn, arc flash, or flame, because the plant design and engineering controls safely limit the current and voltage to which persons can potentially be exposed.

Communications circuits are current-limited and specifically designed so the copper wires can be safely handled bare-handed, even while energized and in use (whether transmitting a voice call, the ringing signal, data, or network power). The maximum steady-state DC voltage, power and current levels are limited to below 200 Vdc (190 Vdc nominal) to ground, 100 watts, and 1.3 amperes, while the instantaneous limits under fault conditions may reach 200 Vdc to ground, 150 watts and 2.4 amperes (all current- and duration-limited in the case of a fault condition to protect personnel). These limits are well within the limits of 400 V to ground and 150 W stated in the OSHA 29 CFR 1910.268(s)(11) as the definition of “communication lines.” All systems that can produce currents above 100 mA through simulated personnel contact conditions are duration-limited (as per Section 7.5 *Duration-Limited Source Requirements* of GR-1089).

Furthermore, there is no risk of arc flash injury from these communications circuits due to insufficient available energy, in accordance as per Section 130.5(B)(1) of the 2023 edition of NFPA 70E, *Standard for Electrical Safety in the Workplace*. Furthermore, Part 68 of the FCC rules (47 CFR Part 68) governs the direct connection of customer premises equipment to the Public Switched Telephone Network (PSTN) and to wireline carrier-owned facilities used to provide private line services and limits the voltage to 56.5 Vdc. Part 68 provides requirements for ringing voltage, including the amount of resistance presented across the communications pair (or to ground), which determines the current flow in the circuit and also determines how quickly the ringing signal is interrupted if a fault or incidental contact occurs.

The circuit design and compliance with the above standards indicate that at these communications circuit voltages and limited currents, and based on normal body resistance, there is no risk of electric shock that could result in either involuntary muscle contraction (sometimes referred to as “let-go”) or ventricular fibrillation.

**Note:** Whether the electricity present on a circuit presents a material health and safety risk is a function of current, voltage, frequency, body resistance and areas of contact and is covered in safety standards such as IEC 60479, Effects of current on human beings and livestock, as well as the functional performance ATIS standard 0600315, Voltage Levels for DC Powered Equipment Used in the Telecommunications Environment.

The communications industry has long recognized that there are potential electrical hazards posed by outside sources such as a power fault, AC induction, or ground faults. Accordingly, the industry has designed, documented, trained, and used a variety of appropriate standard procedures to avoid and protect their workers from those hazards so that it is safe to continue their planned work activities. This safe and conservative approach continues with new powering schemes such as Fault Managed Power Systems as discussed in Section 2.2.1 above.

#### 2.2.2.2 Routine Work of Communications Worker

The routine work of communications workers does not involve removing power supply fuses or contact with high voltages of concern. Generally, if a task involves contact with grid power supply lines or equipment, the practice is to rely on contractual agreements with the power utility that may or may not de-energize such lines and equipment prior to any work.

For example, in the case of downed power lines, the communications worker is not supposed to enter the area or attempt repair of communications lines until the power company is on site and has informed them that it is safe to enter the area.

A general principle of communications work within the vicinity of supply power facilities is for the worker to assume that all supply power lines, apparatus and equipment are energized to the full extent of their rated capacity, and the communications employee should maintain safe working distances well outside the applicable minimum approach distances for the voltage rating.

The combination of operational controls, best practices and maintaining minimum approach distances as listed in [Table 2-2](#) results in a significant safety margin in terms of arc-flash risks.

**Table 2-2 Communications Work Rules and Risk Mitigation Strategies**

| Plant Type/<br>Location         | Situation                                                                                                                                                                            | Mitigation Factors - Practices (*)                                                                                                                                                                                                                    |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aerial plant - Pole             | On pole when power equipment malfunctions or a power fault occurs in power space.                                                                                                    | Communications worker is located at least 40 inches from electrical contacts where arcs could occur. Following best practice guidelines would result in larger distances (e.g., 60+ inches).<br><br>Pole tested with voltage tester before ascending. |
|                                 | Setting replacement pole with power lines/equipment overhead.                                                                                                                        | Communications worker shall be at least 30 feet from possible arc event.<br><br>Voltage rated gloves being used.<br><br>Pole top covered with insulating cover-up.                                                                                    |
| Direct-Buried Plant             | Splicing or working on communications cable with an adjacent power cable.                                                                                                            | Insulating blanket or other cover-up protection used over power cables.<br><br>Power circuits could be de-energized.                                                                                                                                  |
|                                 | Adjacent power pedestal with 480 V-AC transformer adjacent to communications pedestal.                                                                                               | All energized circuits in transformer are in the power pedestal and any arc event should be contained within that box.                                                                                                                                |
|                                 | Cabinet node with 208 AC-power supply – power meter and disconnect switch.                                                                                                           | Power switches are located in separate compartment of the cabinet.<br><br>Any arc-flash effects should be contained within, or moderated by, the meter box.                                                                                           |
| Underground Plant               | Manhole with both power and communications plant.                                                                                                                                    | Standard design and practice is not to have exposed or splice plant of power and communications in same manhole.                                                                                                                                      |
| Drop plant – NEC/NESC Interface | NID and Power meter adjacent.                                                                                                                                                        | Communications work is generally not being performed when power meter/circuits are being set or energized. Work tasks are sequential with all power work completed before communications work begins.                                                 |
| Intra-building Plant            | CO facilities = Hut and CEV facilities = AC-power fed.                                                                                                                               |                                                                                                                                                                                                                                                       |
|                                 | Inside customer building.                                                                                                                                                            |                                                                                                                                                                                                                                                       |
| Inside Power Substation         | Telecom employee working in a power generation plant or substation is under supervision and authority of trained power company employee (see <a href="#">Section 2.2.2.3</a> below). |                                                                                                                                                                                                                                                       |

(\*) **Footnote to Table 2-2:** There are physical collateral dangers to a communications worker from falling equipment and flying debris in the unlikely event that an arc-flash occurs coincidental with a telecom worker executing a task in the adjacent area. Standard pre-work check lists and an alert worker can help prevent a communications worker from being placed in



a hazardous situation including (a) visual inspection of the aerial plant attached to the pole before ascending, (b) being aware of odors indicative of a hazardous condition such as odors of natural gas, gasoline/fuel, gas odor, electrical arc (ozone) or smoke within a manhole before entering a work area, along with testing with explosive gas meters, (c) evidence of leaking transformers, (d) arcing noise from power connections, or (e) scorching marks from previous arcing events. Such situational awareness and common sense precautions are part of the proper training for any communications worker.

Most, if not all, the available test data is correctly focused on the electrical worker doing routine activities such as changing meters, initiating AC power service and closing breakers on large voltage distribution and transmission lines. Calculations for the risks to communications workers in their routine normal work areas were made based on IEEE 1584, NFPA 70E guidance tables, and NESC 410A3 with root cause analysis of arc-flash incidents where assessments of physical injury to worker was available.

The basic input data for the arc-flash calculations were as follows:

- Power equipment under fault is open-air, grounded power equipment with characteristic system voltages of 120 to 480 volts AC (60 Hz); possibly up to 750 volts in occasional cases carrying maximum 3-Phase bolted currents of 10-25kA being present; possibly up to 40-60 kA in occasional cases.
- The duration of the arc event is assumed to be between 1 to 30 cycles, which equates to 0.02 to 0.5 second, with durations between 0.02 to 0.1 second being the more likely interval before the AC protection devices activates and shuts down the power circuit.
- Typical arc lengths of between 6 to 10 mm were used which represent the distance between the conductors or terminal points between which the arc occurs. Larger values (e.g., up to 40 mm) did not affect these arc-flash risk assessments significantly, and such larger gaps are less to produce an arc through the air.
- The distance from the arc to the employee was assumed to be:
  - 18 inches for power utility employee working on equipment
  - 40 to 60 inches minimum for nearby or adjacent communications employee.

Using this data, the calculated arc-flash energy that would be delivered to the communications employee located at 40 to 60 inches from the arc event is between 0.02 to 0.65 cal/cm<sup>2</sup>. These are levels well below the 2 cal/cm<sup>2</sup> criteria in NESC 410A3

and will only require the lowest levels of PPE for the communications worker completing routine work such as those for

- Hazard Risk Category 0 = Non-melting clothing as per ASTM F1506 with a fabric weight of at least 4.5 oz/yd<sup>2</sup>.

In aerial plant, the minimum 40-inch clearance between communications



lines and power lines provides the first operational level of basic safety for the communications worker. Other regulatory and legal clearances for equipment and cables are codified in the NESC and provide another safety layer. Finally, the work practices and the training of the communications employee provide additional protection layers to achieve the highest degree of safety, and lowest risk level, reasonable for a given work situation.

In above-ground plant involving pedestals, handholes, cabinets and wall-mounted equipment enclosures, adequate working and safety spaces are codified in the applicable portions of the NESC and NEC codes. The arc-flash hazard for these sites primarily centers on the AC utility power feeds to these equipment closures. The magnitude of the energy possibly released at these closures depends largely on the amount of material available to be affected and destroyed by an arc, e.g., terminal contacts for power meter, AC power bus bar in a large cabinet. The safety precautions of (a) knowing the electrical hazard's presence obtained through employee training, and (b) maintaining sufficient distance and working space in possible arc situations, are achieved within normal methods and practices of the trained telecommunications worker.

Within the underground plant, the joint-buried environments provide one possible situation where arc-flash hazards may be possible. Joint-use equipment vaults or manholes are non-standard work areas within the underground plant network where a concern exists. Arc flash events inside confined space are potentially very dangerous and extremely difficult to protect against with PPE. The dangers of arc- flash events and direct electrical contact are the main reasons that joint-use manholes (power and telecommunications) are generally avoided. Inside any such joint-use vaults and manholes, it is imperative that best work and safety practices be strictly enforced and followed (e.g., lock-out/tag-out, protective coverings, proper PPE and so forth).

The power present in span powering circuits and FMPS systems is limited by design features, automatic controls and operational protocols to minimize the arc-flash hazard associated with these dedicated powering circuits only used to provide power to communications equipment.

### 2.2.2.3 Communications Worker in Substation

One exception to the general findings above is during communications work performed inside a power substation or generation facility that may require additional protective clothing. However, it shall be the responsibility of the utility power supply company (the controlling authority for the substation) to quantify the arc-flash and other electrical risks in such locations and to provide additional clothing protection and appropriate additional work rules if necessary.

These generation or substation facilities are covered under Part 1 of the NESC code where rules designed to provide fences and barriers to help ensure only authorized and trained persons enter the facility as well as

maintaining sufficient clearances within the area. These clearance, separations, and facility rules combine together to provide sufficient workspace around equipment. Any communications employee entering a power substation should be trained and supervised to maintain full clearance from all powered equipment.

For example, NESC Rule 124 (Table 124-1) contains the rules for guarding live equipment and providing sufficient safety clearance around the equipment with guards -

*....an adequate insulating covering, unless the location gives sufficient horizontal or vertical clearance or a combination of these clearances to limit the likelihood of accidental human contact....*

The assumption is that to access the communications equipment in the substation, the employee shall be on pathways and passageways that maintain him/her at greater than the safety clearance values from any energized equipment, including outside any applicable flash protection boundary. Therefore, the communications technician entering the substation should

- *Have the necessary safety training, and/or*
- *Be under the supervision by a supply employee while in station*
- *Be outside the safety clearance zone for any live supply equipment when he/ she enters, leaves and works in the areas.*

In addition, OSHA in 29 CFR 1910.269 (Rule for Electrical Workers) requires that certain activities in power generation stations cannot be performed by a single employee. At electrical power generation, transmission, and distribution installations of electric utilities, as well as equivalent installations of industrial establishments, OSHA prohibits an employee from working alone on or near energized parts. In 29 CFR 1910.269(l)(1)(i), OSHA requires that at least two employees be present when any of the following types of work are being performed:

- *Installation, removal, or repair of lines that are energized at more than 600 volts*
- *Installation, removal, or repair of de-energized lines if an employee is exposed to contact with other parts energized at more than 600 volts*
- *Installation, removal, or repair of equipment, such as transformers, capacitors, and regulators, if an employee is exposed to contact with parts energized at more than 600 volts*
- *Work involving the use of mechanical equipment, other than insulated aerial lifts, near parts energized at more than 600 volts*

The last bullet item in the above list could include a telecommunications employee working on communications equipment within the substation. The term *near* should be considered to mean that the employee comes within the MAD for the equipment or line, or be in the general vicinity of the equipment (e.g., within 10 feet). The telecom worker should have no reason to be closer

than MAD in any circumstances.

The responsibility of the assessment of the arc threat would need to be with the power supply company, i.e., the owner and operator of the generation plant or substation. If the use of such additional arc-rated PPE clothing creates problems for work (too hot or too cumbersome), then the exceptions to Rule 410-A-3 come into play and permit less protective clothing to be worn.

The bottom line in all these discussions of protective clothing (gloves, cover-ups, blankets, FR shirts, and so forth) is that protective clothing is not a substitute for correct work practices or correct substation construction with adequate clearance space and working areas.

## 2.3 Using Truck-Mounted Equipment Near Power

The person operating the lift, winch, derrick, motor vehicle, etc., must be trained and thoroughly familiar with the equipment and the method of operation.

All the required safety system tests and inspections of the motor vehicles and equipment must be made prior to the start of work operations.

Survey the work location for hazardous conditions, and clearance from power, terrain, traffic, or other situations that could affect the clearance of the boom, pole derrick, basket platform, or employee from power. Ensure that each employee is made aware of the assignment, the nature of the work, and the precautions to be observed.

**Note:** If the minimum clearances cannot be met, refer the condition to your supervisor.

At no time during pole placing, moving, or removal shall the derrick head come any closer than 3 feet (900 mm) to the lowest power conductor unless the voltage is verified below 750 V and confirmed by your supervisor. The 3-foot clearance applies from 750 V up to 34.5 kV phase-to-phase voltages. If the voltage is known to be above 34.5/37 kV, phase-to-phase, the derrick head is never to come closer than 6 feet (1.8 m) to the conductor; and is preferred if a >10-foot clearance is maintained during work operations.

As general guidance for work with truck-mounted equipment near power lines above 20 kV up to 86 kV phase-to-ground (i.e., above 34.5/37 kV to 150 kV phase-to-phase), the derrick head maintains a minimum 15-foot (4.6-m) clearance.

Communications lines are not normally attached to structures with these higher voltages; therefore, each work operation on such joint-use structures should be coordinated with the power supply company. To facilitate the communications work, the supply company may have to insulate the conductor, move the conductor, or de-energize the conductor.

Before starting work operations, place insulating gloves and protectors in the

bucket or basket of the lift vehicle. Remove insulating gloves, protectors, and the insulating blanket from storage and place in the cab of the vehicle, or other location, where they will always be available in the event of an emergency.

All employees handling poles, wire cable strand, or tools must wear insulating gloves and protectors when there is any possibility of a power contact. No parts of the body, other than the glove-protected hands, shall contact the pole, cable, wire, truck, or equipment during the period of possible contact.

The driver of the vehicle shall ensure that no contacts exist between the lift, pole, derrick, etc., and any energized conductor by observation and communications each time he/she enters or leaves the vehicle. If there is any doubt as to whether contact exists, the driver must assume the vehicle is energized.

If a power contact exists, the entire vehicle, its contents, and equipment are energized. No one shall be permitted to contact, enter, or leave the vehicle. If an emergency arises, the following steps must be taken to enter or leave the vehicle:

- **Leaving Truck:** Put on insulating gloves and throw an insulating blanket on the ground. Leaving the vehicle needs to be accomplished in a single process where all contact with the vehicle is broken before contact with the ground or other object is made, e.g., jump off the vehicle onto the blanket. Avoid contact with the grounded objects such as tree limbs, shrubs, personnel, etc., until free and clear of the vehicle.
- **Re-Entering Truck:** Put on insulating gloves, step on the insulating blanket, and break all contact with grounded objects before touching the vehicle.

The critical objective of these work rules and practices is to avoid the individual becoming the preferred conductive path from the energized truck to earth.

It is never permissible for the operator to stand on the ground while operating the winch or derrick controls, even if wearing insulating gloves and standing on an insulating blanket. While standing on a truck platform and operating these controls, the operator need not wear insulating gloves or stand on an insulating blanket, but these protective devices must be within reach for emergency use as instructed above.

## 2.4 Placing or Removing Poles Near Power

The general rule would be to insulate the pole and wear insulating gloves. In order to eliminate these needs for insulating the pole and the wearing of insulating gloves, the work prints, detailed drawings, and job plan must show the voltage of the power conductor and how sufficient safe distance can be maintained during the whole work operation.

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When the pole is within, or will come within, 20 feet (6.1 m) of the power during a placing or removal work operation and the voltage and clearance have not been specified, obtain the line voltage information from the supervisor, communications engineering forces, or the local utility supply company before any work begins.

If the work print indicates that enough distance cannot be maintained and the voltage is 20,000 V or less to ground (34,000 V or less phase-to-phase), the pole must be insulated.

If the voltage is above 20,000 V up to 86,000 V to ground (i.e., above 34.5 kV to 150 kV phase-to-phase), the pole may be placed or removed only if the in-place clearance is 15 feet (4.6 m) or more and the power conductor is, or will be, higher than the in-place pole. If the in-place clearance is less than 15 feet (4.6 m), the power company must be contacted. They may elect to insulate the conductor, move the conductor, de-energize the conductor, or place or remove the pole. No work is to proceed until a responsible employee of the power company confirms one of the options has been completed.

When a pole is being placed or removed, make every effort to prevent contact with power conductors.

All employees handling the pole with their hands or with pike poles or other tools must wear insulating gloves and protectors when there is any possibility of contact with the power conductors. Except for glove-protected hands, do not allow any part of the body to contact the pole, tools, truck, or other equipment that could become energized during the period of power contact.

Before a pole is removed, all attachments must be removed. Electric-supply-company attachments, in all cases, must be removed by the electric company.

On joint-crossing poles, do not place any communications attachments if the power company has not transferred their attachments as they may contact the pole. If the new and old poles are lashed together in such a manner that the movement of one does not result in bringing the power conductors closer to the other, and the power attachments are firmly fixed to the old pole with standard clearance from the planned location of the communications attachments on the new pole, attachment of the communications plant to the new pole may proceed. When an employee must work aloft on a newly placed pole for the purpose of placing the lashing wire or otherwise securing the new and old poles together, the winch, derrick, pike poles, or other tools and equipment used to maintain relative positions of the old and new poles shall remain in place until both poles are firmly secured.

Do not place or remove poles near power wires carrying over 5,000 V to ground during substantial rain, sleet, or wet snowfall.

Before placing, insulate all poles that have been lying in wet snow, water, or mud.

Always attach the winch line above, but close to, the balance point so the butt end is heavy. This allows the derrick head to be as low as possible.

Allow for the rise of the derrick head when the pole is placed in the hole and the weight of the pole is released.

When handling a pole among existing power lines, it may be desirable to position the boom first and then raise or lower the pole by using the winch line so the pole can be more readily guided between the lines.

## 2.5 Placing or Removing Suspension Strand and Cable Near Power

Insulating gloves must be worn by all employees handling the strand, reels, ropes, associated trucks, trailers, etc., during placing, removing, tensioning, dead-ending, and grounding operations on jointly used poles or non-joint poles involving power crossing. Wear insulating gloves and avoid body contact until the strand has been placed in the clamps, tensioned, and dead-ended, and all permanent grounds have been attached where required.

Suspension strand that is being placed must be grounded by the use of the B grounding roller for stationary reel jobs or by grounding to the power company vertical neutral of a common neutral system. The strand must also be grounded when using the moving reel method. A low-resistance ground connection is essential. See [Chapter 10](#) for information on bonding and grounding of aerial plant.

The end of the strand on self-supporting cable should be grounded when using the moving reel method. Extra special precautions to guard against flip-up are required when placing self-supporting cable using the stationary reel method.

All ropes used in conjunction with placing strand on joint-use or power crossing must be dry and free of metallic strand. Never use a winch line when placing or removing strands on joint or power crossing poles.

When using a moving reel method, use care to prevent the strand from whipping or fouling on the reel. Moving the vehicle too fast, the reel not turning smoothly, or improper brake tension can cause whipping of the strand or cable and create a potential power contact.

At upward changes of grade (low poles) on jointly used lines, a block should be lashed at the strand level to prevent the pulling-in of line and strand from power conductors.

When pulling in strand on joint-use or power crossing spans and there is any possibility of the strand whipping up into the power conductors, it should be held down by means of a 3.8 inch (9.5 mm) diameter or larger dry rope until stringing and tensioning operations are complete.

**Note:** Do not place strand over power conductors of 750 V or higher voltage.

To remove lashed cable located above power conductors, remove the lashing wire with the lashing wire remover and place cable blocks to support the cable. Attach a pulling and drag line as well as a rope. Cut the cable; prevent the cable from dropping by maintaining tension on the drag line.

## 2.6 Visual Pole Inspection

All poles must be visually examined before any work operation begins. A work operation involves climbing the pole, placing a ladder against the pole or strand, hanging an aerial platform, riding the strand, or other similar routine operations where an additional load is placed on the pole. While making the visual examination, check the following conditions:

- Leaning of a Pole. Any unexplained leaning of a pole may be due to failure of the pole at or below groundline.
- Insufficient depth of setting. This may be due to erosion of the earth around the pole as a result of heavy rainfall, flood water, road widening, etc., and would affect the stability of the pole. The position of the label or burn mark on the pole is usually (not always) located 10 feet from the pole end (pole butt) and therefore can help indicate the burial depth of the pole depth.
- Evidence of collision damage, particularly when the pole is at an exposed location along a highway. Areas adjacent to bends and corners of the roadway can be especially vulnerable to impact damage.
- Presence of fungus growth in cracks or protruding from the pole surface or on areas near the groundline where the wood appears water-soaked in contrast to surrounding wood. These systems usually indicate a condition of advanced decay in the interior of the pole.
- Presence of termite or carpenter ant infestation, evidenced by mud channels or debris in the cracks, wood dust at the base of the pole, or movement of ants when the pole is struck with a hammer or other tool.
- Bent, loose, or missing pole steps.
- Wide seasoning cracks that could result in loosening of pole steps and present a climbing hazard.
- Evidence of compression wood indicated by short horizontal cracks along the surface of the pole, or by curling of wood away from the pole surface.
- Presence and distribution of large knots, climber gaff splinters, unauthorized signs, aerials, clotheslines, and nearby interfering tree growth.
- Presence of large stones, ground irregularities, debris at the base of pole.
- Presence of conduits or vertical runs on pole that might interfere with the use of pole steps or climbing.
- Broken wires in adjacent span.
- Excessively tight or excessively slack drop or line wires on one side of pole.
- Broken or slack guy wires.
- Contact or insufficient separation between communications and power supply conductors.

- Contact or insufficient separation/clearance between the communications plant and other facilities (hardware, equipment, or conductors) attached to the pole or within spans adjacent to the pole.
- Insufficient climbing space or working space on a pole.
- Woodpecker holes.
- Evidence of lightning or fire damage.
- Presence of markings or pole tags placed by the pole inspector to indicate an unsafe pole or pole to be replaced.
- Presence of ice on the pole surface or pole steps that might result in a hazardous climbing condition.
- Shell rot decay on cedar poles.

Visual inspection is used to ascertain if there is a pole, soil, or load condition that warrants further testing (e.g., sound, prod, or hand-line test) prior to working on the pole.

No work aloft shall be started unless the employee is satisfied that the pole line structure has adequate strength to support the load resulting from working aloft and the load which will result from the intended work operations. If the strength of the pole line structure is in doubt, temporary or permanent supports must be applied before starting work.

Further details on pole inspection and a discussion on test/inspection guidelines for poles are provided in [Section 2.7](#) and [Chapter 12](#) of this document.

## 2.7 Conditions Requiring No Testing or Supplemental Support

It is unnecessary to make tests or to apply a temporary support before climbing a pole if any of the following conditions exist throughout the work operations, unless visual inspection indicates otherwise:

- (a). The pole is storm guyed on four sides -

**Note:** Storm guying refers to extra guys added above the normal guys required for corners, crossings, dead ends, and long spans. These extra guys are designed for higher resistance of the pole line to damage from wind and ice effects. The need for such storm guying usually arises from local experience and specific knowledge of the pole line and local weather/climate conditions.

- (b). The pole carries two or more storm side guys and is configured with 6 M or better strand as described in 2(b).
- (c). The pole is part of a H-fixture provided with head and back guys.
- (d). The pole is not in a straight section of a line, but is an adequately



guyed corner pole and carries a load as described in 2(b) below.

It is also unnecessary to make or apply temporary support before climbing a pole if **all** of the following exist throughout the work operations and the proposed work operations do not involve placing a heavy unbalanced load on the pole:

- (a). The pole is in a straight section of line, but is not a dead-end pole.
- (b). The pole is carrying a 6 M or larger suspension strand securely clamped to it, and to each adjacent pole, and will remain so attached throughout the work operations.
- (c). There is no downward change in grade at the pole.
- (d). Neither adjacent span length is in excess of 165 feet (50 m).

It is also unnecessary to make tests or to provide supplementary supports before climbing a pole if the following conditions exist:

- (a). Instead of carrying a suspension strand, the pole carries ten or more copper, copper steel, or steel line wires that will remain securely tied at the pole and at each adjacent pole throughout the work operation.
- (b). All other conditions described in 2 (a), (c), and (d) exist.

## 2.8 Buried Plant Precautions

Before starting any excavation, drilling or boring operations, locate all foreign plant that may interfere with the proposed communications route. Make every effort to avoid contact with, and damage to, the underground or buried facilities belonging to other utilities, water companies, gas lines, municipalities, etc.

Other companies who have buried or underground facilities should be requested to establish the location of these facilities and to expose, identify, and suitably protect their facilities while work is in process.

If there is a “One-Call Center” and/or a local utility location and coordination committee active in your area, be sure to notify them of scheduled construction activities a minimum of 48 hours before burying operations. Some state and local agencies may have laws that require more lead time than 48 hours; this should be verified in the planning stages of the job. The One-Call Center will notify other subsurface facility operators to locate and mark their plant in the vicinity of the route before construction.

All states in the USA have a One-Call Center. Since 2007, a National One-Call “811” number was operable to facilitate contact with State One-Call notification systems. For program details and contact information, go to [www.call811.com](http://www.call811.com) and/or the Common Ground Alliance (CGA) web site at [www.commongroundalliance.com](http://www.commongroundalliance.com).



Locating devices may be used to locate metallic facilities such as gas pipe, water pipe, cable, etc. These devices should be used ahead of trenching, plowing, pole setting, and pipe-pushing operations. See [Section 19.6, “Locating Technologies for Buried and Underground Plant,”](#) for a discussion on the location technologies.

To prevent damage in areas where other companies’ buried or underground facilities are plastic, such as gas pipe, water pipe, etc., these facilities must be located, exposed, and protected while work is in progress.

When foreign objects are encountered while digging, plowing, trenching, or pipe pushing, **stop operations immediately!** Expose and investigate them with caution. Do not cut, chop through, or break off underground obstructions without first determining if they serve a useful purpose. Under no circumstances should underground electric plant or pipe lines (gas or other) be disturbed.

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**! CAUTION ! If a gas line is broken or damaged:**

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1. Turn off all spark producing equipment.
2. Leave the hole open to allow gas to dissipate into atmosphere.
3. Warn residents and the public in the vicinity.
4. Notify local fire department and local gas company.
5. Keep the public clear of the area until the condition is cleared.
6. Notify your supervisor.



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**! CAUTION ! If a power line is broken or damaged:**

---

1. Barricade the location until the condition has been cleared.
2. Notify the local power company.
3. Keep the public clear of the area and remain on the site until personnel from the power company arrive.
4. Notify your supervisor.



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**! CAUTION ! If a pipeline other than natural gas is broken or damaged:**

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1. If a liquid is noticed that appears to be volatile, such as gasoline or diesel fuel, all work should cease immediately.
2. Notify the appropriate utility, municipality, etc., and remain on the site (at a reasonable distance from the leak to provide safety) until responsible personnel arrive.
3. Notify your supervisor.

## 2.9 Depth of Buried Plant

The distance between the top of a cable and the surface under which it is installed shall be sufficient to protect the cable from damage imposed by expected surface usage. The burial depths as indicated in Tables 2-3 and 2-4 are considered adequate except in areas where frost conditions could damage cables, in which case greater burial depths may be desirable. Lesser depths than indicated may be used where supplemental protection is provided. This supplemental protection should be sufficient to mechanically and thermally protect the cable from damage imposed by expected surface usage that can include placing the cable in a conduit or duct.

Where conduit is required for short, special conditions in buried distribution systems, such as road crossings, separate ducts for power and communications facilities must be provided. These short cable-in-conduit sections are usually not part of a conduit system and should be treated as direct-buried plant that need to meet the requirements of Section 35 of the NESC.

**Note:** Recent proposals have been made for joint placement of low-voltage (dc/ac) power and communications lines for serving wireless sites located in congested urban areas. Such joint-buried situations need to be treated as special cases with supplementary guarding and protection added to

normal buried plant practices (see Chapters 15, 21, 23, and 27 for further discussions), and the engineering organization of the communications company shall be contacted for applicable and approved installation and construction practices.

Direct-buried supply cable or conductor burial depth, as required by the NESC, is shown in [Table 2-3](#).

**Table 2-3 Minimum Depth of Electric Supply Cable**

| Maximum Voltage<br>Phase-to-Phase | Maximum Voltage<br>Phase-to-Ground | Depth of Cover |             |
|-----------------------------------|------------------------------------|----------------|-------------|
|                                   |                                    | Inches         | Millimeters |
| 0 to 600 V                        | 0 to 348 v                         | 24             | 600         |
| 601 V to 50 kV                    | 349 V to 29 kV                     | 30             | 750         |
| 50,001 V and above                | 29,001 V and above                 | 42             | 1070        |

Communications cable and wire burial depths, as recommended by industry practice, are shown in [Table 2-4](#).

**Table 2-4 Minimum Depth of Communications Plant**

| Type of Facility   | Copper |             | Fiber  |             |
|--------------------|--------|-------------|--------|-------------|
|                    | Inches | Millimeters | Inches | Millimeters |
| Toll/Trunk Cable   | 30     | 750         | 30     | 750         |
| Distribution Cable | 24     | 600         | 24     | 600         |
| Service/Drop Wire  | 18     | 300         | 18     | 450         |

Depth of cover for power cables is governed by the NESC. For joint facilities, the minimum depth of cover shall be determined from either [Table 2-3](#) or [Table 2-4](#), using the “greater” depth. The burial depths above are minimum safety depths from the NESC (Rules 351 to 354) based on voltage/amperage risks directed towards electric supply cables. Although some industry guidelines have used a 12-inch value as a minimum value for service drops, it is preferred that all communications drops should be placed at or below 18 inches. Planting a small tree or bush can easily cause surface disturbances to a depth of 12-16 inches or greater; and larger trees requiring more than 20 inches.

## 2.10 Separation from Gas and Other Fuel Lines

The radial separation of communications cables from steam lines, gas, and other fuel lines shall be not less than 12 inches (300 mm) and shall meet NESC Rules 353 and 354. The radial separation should be adequate to permit access to, and maintenance of either the communications cable or the gas or fuel lines, while limiting possible damage to the other facility. In general, any flammable material carried in a pipe or line should be considered a fuel.



Cables should be installed with sufficient separation from steam or cryogenic lines to avoid thermal damage to the cables. Where it is not practical to provide adequate clearance, a suitable thermal barrier shall be placed between the two facilities.

**Note:** Additional requirements for separation from steam lines, gas, and other fuel lines are covered in NESC Rule 353.

### 2.10.1 Steam Lines

Steam damage to communications cables have been a concern for many decades since high-pressure, high-temperature steam systems (380-420°F and ~200 psi) are found in older established cities where often 10-15% of the steam can leak from these older pipe systems. Pipes can be 2 to 30 inches in diameter.

Particularly vulnerable points within the communications plant to steam include splice points, splice cases, and cable jackets. The tapes, seals, gaskets and other materials used to seal splice cases and other hardware are designed for flexibility and cannot usually withstand the high temperatures of steam conditions. Aircore cables may be maintained with a 4-8 psi of internal pressure to help keep the cable core dry. Heating and weakening of their jackets allows the migration of water through the jacket and cracks to develop as this internal air pressure can burst a weakened jacket.

NESC Rule 353D requires (a) sufficient separation to provide thermal protection from steam pipes and cryogenic lines to avoid thermal damage to the cable plant, or (b) a suitable thermal barrier be placed between the cable and the pipes.

The necessary thermal protection can be achieved in various ways, including one or more of the following:

- The steam pipes can be encased in concrete to provide additional thermal protection.

- The communications cables can be placed inside a thermal-resistant duct (i.e., not PVC duct) that can serve as thermal and moisture barriers. Insulated steel ducts and fiber-reinforced epoxy ducts have been used successfully for this purpose.
- The communications cables can be placed inside conduit systems, i.e., a group of ducts or conduits encased in concrete.

High-pressure, high-temperature steam is an aggressive material. Long term steam leakage can over time burrow a passageway through soils and along the outside of conduit runs until it finds an entry point (splice case, manhole, etc..) into a cable or inside a conduit far from the initial steam pipe or leak site.

The minimum radial separation noted in Section 35 of the NESC (Rules 353A and 354A1) is 12 inches with further qualification noted in Rules 353D that requires adequate thermal protection barriers without a specific distance. If the steam pipes are within 3 feet of the buried cable plant, additional thermal protection is advisable.

The 3 feet is provided as an engineering guidance or recommendation clearance and is not an explicit NESC rule. The 3 feet of soil is sufficient to dissipate the pressure/ temperature of the steam and help reduce the thermal softening and melting of cable jackets and slow down (but not stop) the thermal degradation processes that occur.

**Note:** The NESC is primarily an electrical safety rule with a focus on the protection of the employee/ worker and not an engineering document. The value of 3 feet provided here is based on limiting the thermal damage to the communications plant from escaping steam from nearby pipes.

The protection needed for any particular case is greatly affected by local conditions, including factors such as (a) the thermal conductivity of the intervening soil, concrete, conduit walls, cable jackets, and other materials, (b) how much leakage is occurring from the steam pipes, (c) access points into the cable such as holes in jackets, cracks in conduit, splice cases, and (d) accessible channels and voids in the ground through which any escaping steam can move easily, e.g., manhole, conduit lines, loose soil that can be excavated by a water/steam jet from leaking pipes.

## 2.11 Safety Considerations

Before excavating near buried plant, both the cable route and depth of the existing communications cables must be located. The electric power company should locate the route and depth of its power cable(s) and use a staking pattern to show the random lay of the cable(s).

**Note:** Test sets indicate only approximate cable depth, so exercise caution when digging or drilling/boring.

For maintenance, extensions, and new service, the existing cables should be uncovered by hand digging using only tools with wood or fiberglass handles,

or similar insulating material. Do not use digging bars or tools with metal handles. Power digging equipment may be used thereafter for extension in the direction away from the existing cable.

Under normal conditions with stable soil, shoring is not required unless excavations are 5 feet (1.5 m) or more in depth and employees have occasion to enter them. This 5-foot (1.5-m) guide should be modified to lesser depths if unstable soil conditions or rainy weather exist or if heavy equipment or traffic is in proximity to the excavation. Prior to entry, excavations must be inspected by a “competent” person.

**Note:** A “competent person” means someone who has been trained in, and has demonstrated knowledge of, excavation best practices and the hazards associated with such construction methods

**Note:** The OSHA, *Construction Standard for Excavations*, regulates all excavations, including standards. See Regulation Standard 29, CFR Part 1926, “*Safety and Health Regulations for Construction: Subpart P on Excavations*.” ([www.osha.gov](http://www.osha.gov)).

Before handling, opening, or cutting cables, positive electric identification shall be made. Certain electrical supply cables have the outer jacket appearance and characteristics that are very similar to communications cables, which can make visual identification impossible.

**Note:** As stipulated in the NESC, direct-buried jacketed power cables and direct-buried communications cables should be marked by the cable supplier with unique identification symbols. Refer to NESC Rule 350. Older cables may not all be so marked, or the marking may have been abraded off over time in the buried environment.

Communications employees should not move or handle any power cable or power service leads. Power company employees shall be requested to move primary, secondary, and service leads in both main and service trenches.

When damage is suspected or visual observations indicate damage, before any bodily contact is made, test with a 1.88A test set or equivalent voltage tester.

**Note:** If the test indicates the presence of power, immediately remove the test set from contact. Take necessary precautions to protect the public and notify your supervisor.

Electrical continuity of all bonds, including cable sheath bonds in closures or at splice locations, must be maintained during the repair process.

Communications employees shall not connect bonds to power cable neutrals, but should leave loop of grounding conductor of sufficient length for the power company to make this bonding connection if appropriate.

The phrase “power cable neutrals” as referred to here should not be confused with Multi-Grounded Neutral (MGN) or external ground lugs on power closures provided to the communications company for bonding. Most grounded power systems include an MGN that has multiple connections to

ground, which are generally considered to be effectively grounded.

**Note:** The term “effectively grounded” may be understood differently across the communications and supply industries. Within this Blue Book, the term “grounded” or “effectively grounded” is used and shall mean a bonding connection to a supply neutral conductor or, more often, to a grounded system [driven rod, Multi-Grounded Neutral (MGN), etc.] designed to minimize hazard to personnel and having sufficiently low resistance and/or impedance to ground (earth) to permit prompt operation of circuit protective devices.

## 2.12 Manholes

It is imperative that all personnel become familiar with the work rules and testing and ventilation procedures before opening and working in manholes. Chapters 15 and 17 of this document address these rules and procedures. Basic general precautions include the following:

- Before entering the manhole
  - Manhole guards and warning devices shall be set up.
  - Test the atmosphere.
  - Ventilate the manhole and maintain ventilation during work.
- Use a ladder to enter and leave a manhole. Do **not** use cables as steps or means of support.
- Do **not** use open flames or spark-producing equipment. Smoking in manholes or above ground in close proximity to manholes is prohibited.
- Only communications company approved lighting and heating equipment and tools should be used.
- When pulling a cable, be sure sheaves, wheels, and other equipment are secured in a position that will prevent any equipment or pulling lines from contacting the existing cable.
- All cables and associated equipment installed in a manhole shall be properly racked, clamped, or supported; particularly, during cable pulling operations with sheaves, wheels, and other equipment secured. In general, personnel should not be in the manhole during cable pulling operations.

## 2.13 Optical Fibers

Optical fiber cables shall be handled similarly to metallic cables with certain important caveats.

1. During handling, pulling, and placement operations, the technician

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should always remain within specified mechanical tolerances for cable bend, tensile loads and compressive stress limits.

2. Proper safety precautions should be taken in handling the cable ends. All end caps shall remain on the cable. Exposed ends shall be covered to prevent an individual from touching the cable end and embedding a glass fragment into their skin.
3. The technician should always handle all fiber cables assuming it is operational (emitting a laser signal) unless it has been verified there is no emitting laser by an optical instrument.

Individuals working with fiber cable should be familiar with the basic optical safety documents and guidelines such as those found in

- ANSI Z136.1, *American National Standard for the Safe Use of Lasers*
- ANSI Z136.2, *American National Standard for the Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources*.

Detailed discussions about placement and handling of fiber cables are provided in [Chapter 27](#) of this *Blue Book*.

## 2.14 Wireless Facilities

Guidelines for wireless facilities, including antenna placement, supporting hardware and equipment, are found in [Chapter 15](#) (introduced in 2017). Many of the requirements and guidelines described for traditional cabling and support equipment apply to wireless facilities. Chapter 15 of this *Blue Book* has a particular focus on the following:

- (a) RF exposure issues, along with the necessary RF protection programs that workers from all joint users of the pole/structure will need to have, and
- (b) The necessary separations and clearances based on NESC rules, working space, and climbing space requirements. All these mechanical separations and working clearance concerns are similar for all communications elements - wireline and wireless.

The major issue that arises is one of congestion and structural conflicts on the pole/ tower structure or underground zone where multiple utilities and several communications service providers are all trying to deploy lines, equipment and facilities in the same space. Although NESC rules 012 and 013 provide high-level guidance, the chief solution to these issues lies with communications between joint users in all stages of the design, engineering and construction phases of network builds.

The powering schemes for serving these wireless communications can be through metered AC grid power closures, span powering circuits from

communications offices or terminals, or FMPS systems. These powering circuits and schemes are discussed in Chapters 2 (Section 2.2), 14 and 15.

## 2.15 Inspection Checklist

The Inspection Checklist is provided to assist the person making periodic inspections of communications facilities placed on or in communications company supporting structures by authorized parties. Such inspections are often limited to visual inspections from ground level; therefore, some aspects may not be easily checked, e.g., components that are located underground or not visible behind guards, covers, conduits, or inside closures.

The Inspection Checklist includes only those areas of construction that are covered in this manual. Local requirements, routines, or procedures that may be agreed upon by the communications company and the party it authorizes to use its supporting structures would supplement this list. [Table 2-5](#) lists items that should be checked when making periodic inspections. This table should be used as a pointer for the reader to go to the more applicable chapters and sections of the *Blue Book*. In general, the applicable information and guidance for any transmission media and application environment is spread across the *Blue Book*, and users should review all applicable chapters.

**Table 2-5 Inspection Checklist**

| Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reference                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Whether the party attaching to supporting structures has acquired the proper authorization from the communications company<br>Joint-Use Agreement (JUA)                                                                                                                                                                                                                                                                                                                                                             | Chapters <a href="#">3</a> , <a href="#">14</a> , <a href="#">15</a> and <a href="#">26</a>                                                                                                                              |
| 2. Proper Clearances: Working and Climbing Space: <ul style="list-style-type: none"> <li>(a) Between Communications Facilities</li> <li>(b) Between Licensee Power Supply and Communications Facilities</li> <li>(c) Between Communications and Power Facilities</li> <li>(d) Vertical Clearances at Rail Crossings</li> <li>(e) Vertical Clearances of Lines above Roads, etc.</li> <li>(f) Adequate Climbing Space and Working Space</li> <li>(g) Wireless Facilities - mechanical clearances/separations</li> </ul> | <a href="#">Section 3.2</a><br><a href="#">Chapter 14</a><br><a href="#">Chapter 3</a><br><a href="#">Chapter 3</a><br><a href="#">Section 3.4</a><br><a href="#">Section 3.9 and 14.1</a><br><a href="#">Chapter 15</a> |
| 3. Wireless - RF exposure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <a href="#">Chapter 15</a>                                                                                                                                                                                               |
| 4. Bonding and Grounding (Aerial)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Chapters <a href="#">10</a> and <a href="#">15</a>                                                                                                                                                                       |
| 5. Bonding - in Manholes and Handholes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <a href="#">Chapter 18</a>                                                                                                                                                                                               |

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| Item                                                                                                                                                                                                                                                                                                                              | Reference                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| 6. Strand - Selecting Correct Strand Size and Tension                                                                                                                                                                                                                                                                             | <a href="#">Chapter 4</a>                                                                                                  |
| 7. Guying (based on L/H Ratio and Size of Suspension Strand):<br>(a) Proper Hardware to Dead-End the Strand<br>(b) Size of Guy Strand<br>(c) Guying, General<br>(d) Anchors and Guy Rods                                                                                                                                          | <a href="#">Chapter 5</a><br><a href="#">Section 5.7</a><br><a href="#">Chapter 6</a><br><a href="#">Chapter 8</a>         |
| 8. Sidewalk Guying                                                                                                                                                                                                                                                                                                                | <a href="#">Section 6.2 and 6.7</a>                                                                                        |
| 9. Insulating Guys                                                                                                                                                                                                                                                                                                                | <a href="#">Chapter 7</a>                                                                                                  |
| 10. False Dead-Ending                                                                                                                                                                                                                                                                                                             | <a href="#">Chapter 9</a>                                                                                                  |
| 11. Identifying Cable (Aerial) and Labeling Facilities for RF safety and identification of responsible party                                                                                                                                                                                                                      | <a href="#">Chapters 11 and 15</a>                                                                                         |
| 12. Proper and appropriate bonding and grounding in aerial plant                                                                                                                                                                                                                                                                  | <a href="#">Chapter 10</a>                                                                                                 |
| 13. Identifying Cable (Underground)                                                                                                                                                                                                                                                                                               | <a href="#">Chapter 19</a>                                                                                                 |
| 14. Sealing Ducts and Conduits                                                                                                                                                                                                                                                                                                    | <a href="#">Chapter 20</a>                                                                                                 |
| 15. General Items To Be Checked:<br>(a) Pole condition and aerial plant configuration.<br>(b) Minimum of 4 inches (100 mm) between bolt holes.<br>(c) Minimum of 4 inches from top of pole to bolt hole.<br>(d) No power wires in manholes. (except for approved portable lights/tools with power connection outside of manhole.) | <a href="#">Chapters 12 and 13</a><br><a href="#">Chapter 3</a><br><a href="#">Chapter 3</a><br><a href="#">Chapter 16</a> |
| 16. Buried Plant Construction                                                                                                                                                                                                                                                                                                     | <a href="#">Chapter 21</a>                                                                                                 |
| 17. Bonding Requirements for Communications Drop Wire                                                                                                                                                                                                                                                                             | <a href="#">Chapter 25</a>                                                                                                 |
| 18. Specific Concerns on Fiber Cable and FTTx Plant                                                                                                                                                                                                                                                                               | <a href="#">Chapter 27</a>                                                                                                 |
| 19. Graphic Symbols for Grid and Mapping Diagrams                                                                                                                                                                                                                                                                                 | <a href="#">Chapter 28</a>                                                                                                 |

These inspections shall be completed at logical times and at such intervals that experience has shown to be necessary and practical. Such logical times could include the following:

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- During pre-survey for new work – upgrades to existing plant, over-building to provide more capacity, or new construction
- At installation of new cables, equipment, or facilities
- During routine repair and maintenance activities
- As part of routine plant reviews and inventory assessments, e.g., pole inspection programs as described in [Section 12.5, “Wooden Pole Inspection Programs.”](#)

As a result of these inspections, if any condition or defect is found that affects safety or compliance with the NESC, then such a condition/defect should be reported to a supervisor, and documented. If the condition/defect with the lines or equipment is such that would reasonably be expected to endanger life or property, then it should be promptly corrected or the lines/equipment should be disconnected or isolated.

During these surveys, more liberty should be encouraged to identify advisory factors that may lead to problems in the future or that may affect long-term reliability of the facilities of any joint users of the pole or easement areas. Advisory factors are those that are not immediate safety issues or code violations, but may lead to future problems for networks or services of any of the joint-user stakeholders. Such factors could include road-widening projects planned, housing developments being planned or under construction, environmental changes to water run-off patterns and vegetation growth, or other changes that can reasonably be expected to affect facilities and services in the future.

### 2.15.1 Inspection and Test – NESC Rules 214 and 313

The best practices to meet the objectives of inspection and test Rule 214 (and its underground companion Rule 313) require utilities to have clear training materials, documentation of practices and outside plant records to limit liability, lower risk, and help avoid premature equipment failures that result in service disruption and long restoration times.

Flexibility is necessary within the language of Rule 214 (and 313) but it behooves each utility to have best practices clearly defined for its workforce and documentation to limit risk of service loss and legal liability for accidents. The sections in the Blue Book shall be further updated with advice and guidance on these inspections, tests and risk management issues.

The inspection of poles is often regulated by state PUCs. Inspections and testing frequency for other plant items is left to the “experience” of the utility or service/network provider. Without clear M&Ps, documentation and records, the utility may be open to claims for compensation in the case of accidents.

## 2.16 Make-Ready Survey Checklist

The Make-Ready Survey Checklist ([Table 2-6](#)) is provided to assist the person conducting a make-ready survey of existing communications company supporting structures in preparation for attachments by authorized parties requesting attachments.

The Make-Ready Surveys primarily rely on the visual inspection of the routes and surrounding area, but should be coupled with the experience of the inspector along with local knowledge of work center managers and local technicians.

The Make-Ready Survey Checklist includes only those areas of construction that are covered in this manual. Local requirements, routines, or procedures that may be agreed upon by the communications company and the party it authorizes to use its supporting structures would supplement this list.

Make-ready surveys and checklists have become more frequent as the number of attachment requests associated with new wireless installations has increased to meet demand.

### 2.16.1 Internet and NESC Resources

Current developments and trends continue to broaden on-line services and on-demand remote access capability to help improve the make-ready process by integrating real-time field data/ photographs/observations, with design and engineering groups as well as on-line code requirements. It is anticipated that some of the design/engineering processes of assessing clearances, pole loading capacity checks, tension and sag verifications, will be made very much more efficient. Hand-held smart devices and rapid access to large engineering databases will enable less field visits and re-work actions.

The lists in Tables 2-6 are illustrative of typical make-ready situations and should not be considered comprehensive for every scenario. As new communications plant is added and replaced to supporting structures, the need for new more customized checklists will develop depending on the communications technology, and powering configurations being used.

**Table 2-6 Make-Ready Survey Checklist**

| Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Reference                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Whether the party attaching to supporting structures has acquired the proper authorization from the communications company.</p> <p>(a) Review cable identification markers and pole labels to ascertain ownership and type of already installed cables, guys and other facilities.</p>                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Chapters 3, 14, and 26 (JUA)</p> <p>Chapters 11 &amp; 19</p> <p>Chapter 15 (WiTF)</p>                                                    |
| <p>2. Proper Clearance:</p> <p>(a) Between Communications facilities</p> <p>(b) Between Licensee Power Supply/Communications Facilities</p> <p>(c) Between Communications and Power Facilities</p> <p>(d) Vertical Clearances at Rail Crossings</p> <p>(e) Clearances of Guys/Cables above Roads and other Structures</p> <p>(f) Climbing Space and Working Space</p> <p>(g) GO 95 and GO 128 Clearances</p>                                                                                                                                                                                                                                                                                                   | <p>Section 3.2</p> <p>Chapter 14</p> <p>Chapter 3</p> <p>Chapter 3</p> <p>Section 3.4</p> <p>Section 3.5, 3.9, 14.1</p> <p>Section 26.4</p> |
| <p>3. Wireless Facilities - Determine the anticipated RF exposure for utility workers on pole and the permitted approach distances to antennas based on power levels and distribution pattern is adequate.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>Chapter 15</p>                                                                                                                           |
| <p>4. Proposed Attachments:</p> <p>(a) Shall be placed in the same relative position on the pole</p> <p>(b) Shall not exceed pole load capacity</p> <p>(c) Determine the preferred point of attachment (height and location) of proposed attachment on a pole-by-pole basis</p> <p>(d) Maintain a minimum of 4 inches (100 mm) between bolt holes.</p> <p>The engineering assessments for the items listed above are in the process of moving to an on-line process completed (at least in part) during the real-time observations in the field.</p>                                                                                                                                                           | <p>Section 3.2.1</p> <p>Chapters 4 and 13</p> <p>Chapter 3</p> <p>Chapter 3</p>                                                             |
| <p>5. Compliance with NESC Clearance:</p> <p>(a) Pole condition and aerial plant configuration</p> <p>(b) Minimum ground clearances for lowest attachments proposed in the communications space</p> <p>(c) Minimum mid-span clearances between proposed and existing facilities must be maintained for all, including the lowest cable in the communications space</p> <p>(d) Evidence that proposed attachments meet tension requirements for applicable storm loading (light, medium, heavy)</p> <p>(e) Any attachments, including temporary attachments, that do not meet clearance and safety requirements are not permitted</p> <p>Such compliance assessments may benefit from use of on-line tools.</p> | <p>Chapters 12 &amp; 13</p> <p>Chapter 3</p> <p>Chapter 3</p> <p>Section 4.1</p> <p>Chapters 3 and 4</p>                                    |

| Item                                                                                                                                                                                                                                                                                               | Reference                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| 6. Consideration for any necessary tree trimming and clearing to accommodate proposed attachments as applicable.                                                                                                                                                                                   | <a href="#">Chapter 3</a> and <a href="#">NESC Rule 218</a>                                                               |
| 7. Proposed and existing bonding and grounding (Aerial), e.g., are there missing bonds or identifying any re-configuration that may be necessary for effective grounding of plant.                                                                                                                 | <a href="#">Chapters 10</a> and <a href="#">14</a>                                                                        |
| 8. Proposed and existing bonding in handholes and manholes, e.g., adequate attachment points and quality of available ground (earth) connection.                                                                                                                                                   | <a href="#">Chapters 16</a> and <a href="#">17</a>                                                                        |
| 9. Strand - Selecting correct strand size and tension. Where applicable, consider using overlap construction methods rather than placing new strand.                                                                                                                                               | <a href="#">Chapter 4</a>                                                                                                 |
| 10. Proposed and Existing guying - will re-guying be necessary - which is related to loading calculations noted above.<br>(a) Proper hardware to dead-end the strand<br>(b) Size of guy strand<br>(c) Guying and need for sidewalk, insulating, false dead-ends, etc.<br>(d) Anchors and guy rods. | <a href="#">Chapter 5</a><br><a href="#">Section 5.7</a><br><a href="#">Chapters 6, 7, 9</a><br><a href="#">Chapter 8</a> |
| 11. Presurvey for Fiber Cable and FTTx Plant Placement                                                                                                                                                                                                                                             | <a href="#">Chapters 14 &amp; 27</a>                                                                                      |

## 2.17 Personal Protection Equipment (PPE)

There are shared responsibilities for employers to provide and employees to use and maintain PPE for the task that is performed. Besides the adequate supply and accessibility of first-aid equipment and materials, there are various common PPE devices that are assumed to be with, used by, or readily available on request to all workers, including:

- Hardhat and safety glasses.
- Insulated tools and apparel such as rubber gloves, rubber sleeves and headgear. Note that standard work gloves do provide some electrical insulating capability for the low-voltage, low-power communications circuits. However, insulating mats and shields and covers may also be necessary for communications workers depending on their proximity to supply power circuits on/in joint-use structures or areas.
- Face and eye protection commensurate with job activity. This would include arc-flash rated clothing if necessary to the risk involved. Note that based on qualitative and quantitative arc-flash risk assessments, coupled with review of best work practices and engineering control options, communications employees in their normal work positions and environments do not require enhanced Fire-Retardant (FR) protective clothing to complete their tasks safely.

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The engineering design of communications networks, coupled with routine work controls and best practices employed during communications activities, help to minimize arc-flash risks and contact hazards with electrical power lines and equipment.

- Portable danger signs, traffic cones, flashers, tags, manhole barriers and other devices to warn and alert the public and other workers in the area as well as to prevent accidental entry by unauthorized persons into an active work zone.
- Fall protection and fall arrest equipment - Line worker body belts, lanyards, positioning straps, and climbing harnesses. Fall protection devices shall not use non-locking hooks and shall not have 100% leather straps.
- Portable fire extinguishing equipment designed for use on electrical fires and approved for use in communications facilities (e.g., huts and CEVs).
- Protective grounding materials - grounding straps, Electrostatic Discharge (ESD) wrist straps, etc.
- Voltage detector devices and meters
- RF meters for those technicians that routinely work on or around wireless antennas. Because of the widespread deployment of wireless equipment, the RF meter usage may expand to many other workers who need to work on joint-use supporting structures where antennas are present.
- Means to clearly identify and locate the communications lines (and nearby power supply lines) before work is undertaken. This can include engineering diagrams, plats/plans, and/or location marks identified by the Call-811 service.

Inherent assumptions for this equipment are that the worker has been trained and authorized for the job being performed with full understanding of the proper use, care, and maintenance of the PPE, as well as that they follow the best practices in using the PPE routinely such as detailed in:

— Bellcore (Telcordia) Practice, BR-081-710-200, *Insulating Gloves, Leather Protectors, Fabric Liners, and Glove Bag - Description and Use*.

All this PPE equipment should have industry standards for quality and functional performance (see examples below), as well as internal procedures from the employer for their inspection, care and maintenance based on the manufacturer's recommendations that should be followed.

— ASTM D120, *Standard Specification for Rubber Insulating Gloves*.

— ASTM F496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves*.

— ASTM F1236, *Standard Guide for Visual Inspection of Electrical Protective Rubber Products*.

— ASTM F1506, *Standard Performance Specification for Flame Resistant and*



*Arc Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards.*

- ASTM F1701, *Standard Specification for Unused Rope with Special Electrical Properties.*
- ASTM F1959, *Standard Test Method for Determining the Arc Rating of Materials for Clothing.*
- ASTM F2178, *Standard Test Method for Determining the Arc Rating and Standard Specification for Eye or Face Protective Products.*
- ASTM F2302, *Standard Performance Specification for Labeling Protective Clothing as Heat and Flame Resistant.*

## 3 Clearances

### 3.1 General

In this chapter, the minimum clearances for communications facilities above roadways, railroad tracks, and other structures or objects; clearances between communications and power facilities; and requirements for climbing space are in accordance with the rules of Section 23 of the NESC 2023 Edition. Clearances between communications facilities of different companies or of the same company are in accordance with the communications industry best practices. All these clearances are minimum values; therefore, for design purposes and in the interest of safety, the reader is encouraged to employ greater clearances and separations where practical.

Conductor clearance is generally based upon the worst case condition (“closest approach”), which will occur at either 120°F (50°C) or under ice loading conditions for the loading area involved. For example, the clearances shown in [Table 3-4](#) are intended to be applied under maximum sag conditions. Thus, the minimum allowable clearances at actual time of installation, e.g., at nominal conditions of 60°F (15°C) and no wind, of communications facilities over roadways, railroads, and other structures will depend on the span length and storm-loading area. Additional separation must be provided to allow for subsequent conductor or cable sag under temperature or ice conditions. In general, in order to implement the various clearance rules described in this section, it will also be necessary to contact the local power company for sag information on its conductors, as well as the communications company (or the licensee) for the corresponding communications cable (including messenger) sag information.

To determine some of the clearances required, it is necessary to know the voltage of the power wires and whether they are part of a grounded system. Clearances for grounded power systems are based on their voltage to ground, unless otherwise indicated. For other systems, clearances depend on the voltage between conductors (phases). Most grounded power systems include a grounded conductor that has many connections to ground. These conductors are called Multi-Grounded Neutrals (MGN) and are generally considered to be “effectively grounded”.

**Note:** Within this Blue Book, the term “grounded” is used and shall mean a bonding connection to a supply neutral conductor or, more often, to a grounded system (driven rod, MGN, etc.) designed to minimize hazard to personnel and having sufficiently low resistance and/or impedance to ground (earth) to permit prompt operation of circuit protective devices. The bonding and/or grounding conductor shall be large enough to carry possible available fault currents. When used in the Blue Book, the term “grounded” shall be interpreted to meet the usual definition of “effectively grounded.” that normally equates to 4 grounds in every mile.

Some localities have codes that are more stringent than the NESC requirements covered in this section. In these localities, the requirements

must comply with the local codes (See Section 26.4 on discussion on General Orders GO95 and GO128).

Whereas new installations and extensions of utility lines and facilities are required to comply with the latest NESC Edition, it is also desirable, where practical, for additions, alterations, or replacements to also be brought into compliance with the latest edition. Since the NESC code is not retroactive (see NESC Rule 013), one does not need to meet current code in every circumstances. As long as the modifications or replacement are in accordance with the rules in effect at the time of the original installation, there is not a strict requirement to upgrade the facility to the latest code.

For historical background and commentary on general approaches and calculations of clearances within the NESC, refer to [Chapter 13](#), [Appendix A](#) and [Appendix C](#).

### 3.2 Clearances Between Communications Facilities

The clearance between communications cables supported on different suspension strands must be at least 12 inches (300 mm) at the pole. In most cases, this will be a vertical clearance, but there are exceptions as explained in this section. Experience has shown that the 12-inch (300-mm) minimum clearance may be reduced as shown in [Figure 3-1](#), provided the diagonal clearance is 12 inches (300 mm), and a minimum of 4 inches (100 mm) between bolt holes is maintained. (Diagonal clearances apply to communications facilities only; diagonal clearances never apply to separation from power facilities.)

**Note:** The terms “suspension strand”, “messenger strand” and “strand” are used across the communications industry and usually all apply to the multistranded galvanized steel wire rope that is placed between poles under appropriate sag and tension to which the communications cables are secured to the rope with lashing wire or hung off rings or hoops. In addition closures and equipment boxes can be secured or “strand-mounted” to the wire rope with brackets.

The NESC 235H clearances are to prevent abrasion and mechanical damage from communications cables coming in contact, as well as to provide adequate working space for the communications workers (from one or different companies) who need access to adjacent lines and equipment.

Communications cables in question do not pose electrical safety threats to the other workers on the pole.

A general design principle is to sag adjacent messengers so they run parallel across the span so that the messenger strands should be kept 12 inches apart across the span. The 4 inches is measured between the cables and equipment that is mounted on the strand to allow for multiple cables on the strand or varying weights that affect the sags of the lines. Strand-mounted splice cases

can be large. So the 4 inches is a minimum practical separation given that we do not know what all the different sizes, weights and types of equipment are to be supported on the messenger strand. Furthermore, one can use a spacer bracket to attain the 4 inches and avoid any undesired physical contact.

The 2023 NESC Rule 235H rules require a minimum of a

- 12-inch (300-mm) radial separation of messengers at the support (not between the cables, but between messenger strands or, more precisely, between attachment points on the pole)
- 4-inch (100-mm) separation between cables/conductors anywhere in the span.

The minimum of 4 inches should be met under all expected conditions of temperature and ice loadings; e.g., in both summer and winter with both cables under the same conditions. A basic design separation of 6 inches should be used so as to exceed this 4-inch minimum and provide added safety

.

During installation of communications lines, adjacent cables/strands are usually held out of the way when lashing machines are used. Having that 12-inch separation between the adjacent messenger strands helps to provide adequate working space between lines during such cable installation processes.

Where more than one licensee's cable is attached, the licensee's cables may be closer than 12 inches (300 mm) from each other at the pole if all the parties involved agree. However, the bolt holes must never be closer than 4 inches (100 mm).

Since pole-mounted cabinets are of various sizes and shapes, it is impractical to establish firm locations for all facilities. However, pole-mounted cabinets must be located to provide the following:

- Sufficient clearance from power facilities – similar rules as for cables
- Sufficient climbing space
- Minimum impairment to ability to perform necessary work operations at terminals
- Minimum ground clearances (also see [Chapter 14](#)).

The recommended location of licensee power supplies, a frequently used pole-mounted facility, is covered in [Chapter 14](#). When locating other pole-mounted facilities, consult with the communications company for the best location. See [Chapter 15](#) on placement and requirements for adding wireless facilities (antenna and support equipment).

**Figure 3-1 Clearance Between Licensee-Owned and Communications Company Cables**

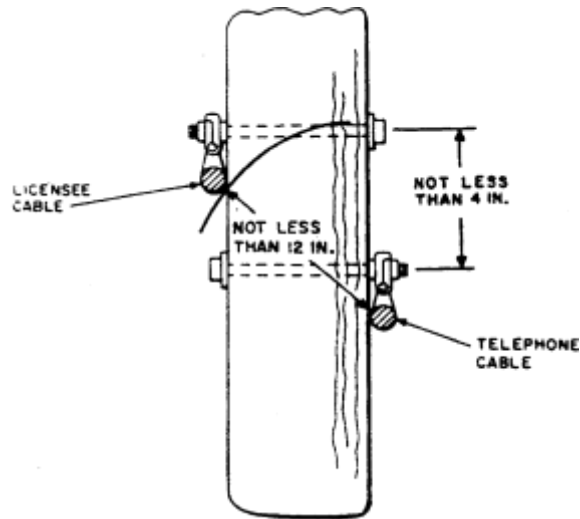
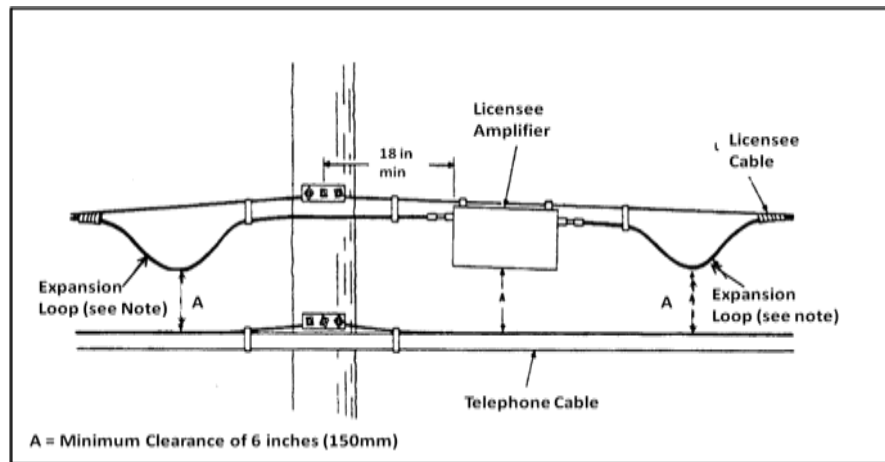


**Figure 3-2 Vertical Separation Between Strand-Mounted Equipment and Other Cable**



**Note:** Expansion loop should be placed to the right or left side of the pole with a minimum of 10 inches (250 mm) from the bolt to the first coaxial cable equipment attachment (e.g., amplifier).

Pole-mounted cabinets of any significant size should not be placed on poles where the following types of communications equipment are already installed:

**Note:** The definition of what defines a “significant size” is variable based on the shape and function of the equipment. In GR-487-CORE, *Telcordia Generic Requirements for Electronic Equipment Cabinets*, a small

cabinet is defined as a cabinet with less than 8 cubic feet. Depending on equipment, even small pieces of less than 2 cubic feet weighing a pound or two can create safety hazards associated with climbing and working space.

- Vertical riser cable transitioning from the underground to aerial plant (including electrical facilities)
- Cross-connecting or distribution terminals
- Splice closures
- Apparatus and Loading coil cases
- Air dryers or any other equipment of significant size.

The concerns about cabinets and equipment size is that multiple attachments create congested poles and can cause safety concerns by:

- Reducing the working space around, and accessibility to, other equipment from joint-user facilities on the pole
- Impeding the climbing space for the pole climber
- Creating cramped and uncomfortable work positions for the worker
- Increasing levels of Electromagnetic Interference (EMI) or RF interference problems degrading the functional performance of adjacent communications equipment and their services.

On non-joint-use poles, the minimum allowable distance between the top of the pole and a bolt hole is 10 inches (250 mm).

A minimum vertical clearance of 6 inches (150 mm) must be maintained between any strand-mounted equipment or coaxial cable expansion loops and communications cable, as shown in [Figure 3-2](#). Detailed information on locating strand-mounted equipment can be found in [Chapter 14](#), with auxiliary related information in [Chapters 15 \(Wireless Facilities\)](#) and [27 \(Optical Fiber Networks\)](#).

### 3.2.1 Hierarchy on Pole

Power lines and facilities should always be located at the top of the pole with communications lines lower down, in line with the recommendation of NESC Rule 220. Wireless antennas may often be found in the upper pole sections (see [Chapter 15](#) for more detailed discussions on possible locations for antennas).

Within the communications space on the pole, considerations of cable characteristics (weight per foot, diameter, sag characteristics, etc.) should determine preferred hierarchy on the pole. Given the heavier nature of metallic pair traditional communications (telephony) plant, it is recommended that optical fiber and coaxial communications plant be placed above existing metallic pair communications plant as long as this is possible

without compromising the 40 inches of separation between communications space and electrical power space on the pole.

Since the high count multi-pair metallic (PIC) cables are usually heavier and larger in diameter, they will tend to have larger sags and ice/wind load factors than the modern fiber or coaxial cables, locating these metallic cables as the lowest on the pole will provide an additional safety factor to avoid physical contact or interference between different communications cables and between cable plant of different telecom carrier companies.

Accommodations may be required to maintain separations where expansion loops in the coaxial distribution cables occur and cable storage loops in optical fiber cable runs are present. Maintaining uniform hierarchy (order) on the pole will also help maintain separation between different utilities and attachers to the pole, and thereby help ensure adequate and consistent working space for technicians from each company working on their plant on the pole. If it becomes necessary to rearrange plant or erect taller poles to maintain minimum separation and clearances, then not only safety and adequate work space, but also cost and contractual pole parity concerns, will need to be considered.

Whatever hierarchy of plant between the licensee's and pole owner's plant is used, the minimum mid-span ground clearances and separation between plant shall be maintained (or exceeded) under all expected conditions.

To avoid the interference, abrasion damage and service problems that can occur, the different communications service providers in the communications space on a pole need to agree on consistent joint-use rules ([Chapter 26](#)) to avoid having expansion loops for coaxial cables, strand-mounted closures, and fiber storage loops all occurring at a single pole. Engineering flexibility needs to be available to the construction crew to enable expansion and storage loops to be moved to the next pole or next span. If options are limited, then the use of cable spacers may be necessary to avoid the interference and abrasion problems.

### 3.3 Clearance Between Power and Communications Facilities

#### 3.3.1 Congestion on Poles

As networks grow and expand, there has been a marked increase in the number and type of equipment being attached to towers and poles, both communications and supply equipment. The competition for attachment space on a pole has come from the expansion of broadband and wireless services requiring the deployments of many Smart-Grid, 5G/6G wireless and other devices.

**Note:** The term "Smart-Grid" includes a wide range of devices that include 2-way communications capability and the ability to remotely monitor, report and control devices within the utility supply network as well as residential and commercial facilities.

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Some of the additional devices attached to poles include:

1. Wireless communications equipment – Antennas, power supplies, and associated devices that will be increased in density to deliver the 5G/6G and other enhanced services.
2. Smart-Grid devices to monitor and control utility power supply circuits and control devices (arrestors, breakers, and switches).
3. Traffic monitor and control devices – Cameras and monitors for control and security surveillance associated with DOTs, police, airport, and homeland security systems need multiple interconnected cameras and antenna units to maximize coverage and diversity.
4. Luminaries – Street lights, as well as in private lighting/luminary systems for parking lots and sports arenas. This includes intelligent lighting systems with automatic controls or allowing customer control of the individual street lights.
5. More and larger communications cross-connect and switching cabinets/boxes – These components are associated with broadband communications services provided through traditional Fiber-To-The-Node (FTTN)/home architectures of communications companies as well as more control and support equipment to provide the backhaul connections for the advanced wireless networks. These include:
  - Cabinets for cross-connections and switch functions of VRAD, U-verse, Fios, xDSL, FTTx type services
  - Nodes to serve the new additional wireless antennas required to enable 4G/ 5G type communications to provide full capabilities across the entire coverage areas for all users.
6. Distributed power sources, including large 3-foot x 5-foot photovoltaic (PV) panels that generate power locally for powering individual remote sites and/or to feed that generated power into the grid.
7. Expansion of private networks with Hybrid Fiber Coaxial (HFC) and wireless (WiFi) architectures.

The consequences of these multiple attachments and congested poles will include poles with less available climbing space and working space, as well as confusion about what is communications equipment and what is supply equipment. Such confusion should not be allowed to compromise having the adequate clearance and separation between equipment on the pole, tower, or structure.

Factors that need to be considered in determining the adequate clearance between conductors, equipment and all the different items attached to the

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pole include the following:

A. Electrical hazard levels for workers in the vicinity of the equipment

- DC- or AC-voltage levels
- Operating voltage and power levels of the equipment
- Grounding and bonding of equipment and closures
- Protection devices and schemes present.

B. Physical size and position on pole

- Sufficient climbing space for all joint users of the pole
- Sufficient working space on the pole for installation and maintenance activities.

Accurate identification of electrical hazard is dependent on equipment type, design, function and interconnection with the supply grid conductors. The traditional Communications Workers Safety Zone (CWSZ) of a 40-inch separation is being compromised with more supply-type equipment being located in and below the traditional communications space.

See [Chapter 14, “Supply Equipment In or Near the Communications Space,”](#) and [Chapter 15, “Wireless Facilities on Utility Poles and Similar Structures,”](#) for more information on specific equipment and hazards.

### 3.3.2 Clearances Between Power and Communications Facilities

The clearances at the pole between power facilities and metallic parts of a communications facility that do not normally carry a current are given in [Table 3-1](#). [Figure 3- 3](#) through [Figure 3-5](#) are referenced in [Table 3-1](#). The clearances are based on Rules 235 and 238 of the NESC.

Cable extension arms or standoff assemblies may be used to support cable, when necessary, to accomplish the following:

- Clear obstructions in the span
- Improve cable alignment.

When extension arms or standoff assemblies are being considered, obtain permission from the communications company for its use, type, location, and method of installation.

**Table 3-1 Minimum Vertical Clearances Between Power Facilities and Noncurrent- Carrying Parts of Communications Facilities on Poles**

| Facility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Clearance                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Open Supply Conductors, 0 to 8.7 kV (Figure 3-3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 40 inches                                                                                                                       |
| Open Supply Conductors, 8.7 to 50 kV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | [Note 1]                                                                                                                        |
| Shielded or insulated, grounded, supply cables or neutrals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 40 inches [Note 2]                                                                                                              |
| Transformer case or capacitor case (non-grounded) 0 to 8.7 kV (Figure 3-4)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 40 inches                                                                                                                       |
| Transformer case or capacitor case (grounded as uniform practice throughout a well-defined area) 0 to 8.7 kV (Figure 3-4)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30 inches                                                                                                                       |
| Transformer case or capacitor case (non-grounded) over 8.7 kV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | [Note 1]                                                                                                                        |
| Streetlight and traffic-signal bracket (non-grounded) (Figure 3-5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 40 inches [Note 3]                                                                                                              |
| Streetlight and traffic-signal bracket (grounded) (Figure 3-5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4 inches [Note 3]                                                                                                               |
| Drip loop of a streetlight bracket (Figure 3-5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 12 inches                                                                                                                       |
| Licensee standoff assemblies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 40 inches                                                                                                                       |
| Supply equipment used exclusively in operation of communications circuits. See Chapter 14 for a detailed description and schematics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 30 inches below lowest communications cable                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 12 inches above highest communications cable                                                                                    |
| Supply equipment meeting all the following criteria: <ul style="list-style-type: none"> <li>• Conductive portions of cases and support hardware are grounded.</li> <li>• Operate at potentials not exceeding those specified for communications lines except for, if applicable, the circuit connecting the equipment to the supply line.</li> <li>• The voltage of the electrical circuits connecting the equipment to the supply line shall not be greater than 150 V.</li> <li>• The equipment circuits shall be electrically isolated from any circuits connecting the equipment to a supply line (e.g., equipment containing inverters shall utilize transformer isolation, and the inverter shall pass the Dielectric Voltage-Withstand Test of UL 1741).</li> <li>• If the equipment provides energy to a supply circuit, it shall meet the requirements of IEEE 1547.</li> </ul> | 30 inches (objective)<br>12 inches (permitted under agreement)<br>(see Section 3.3.3 and Chapter 14 for a detailed description) |

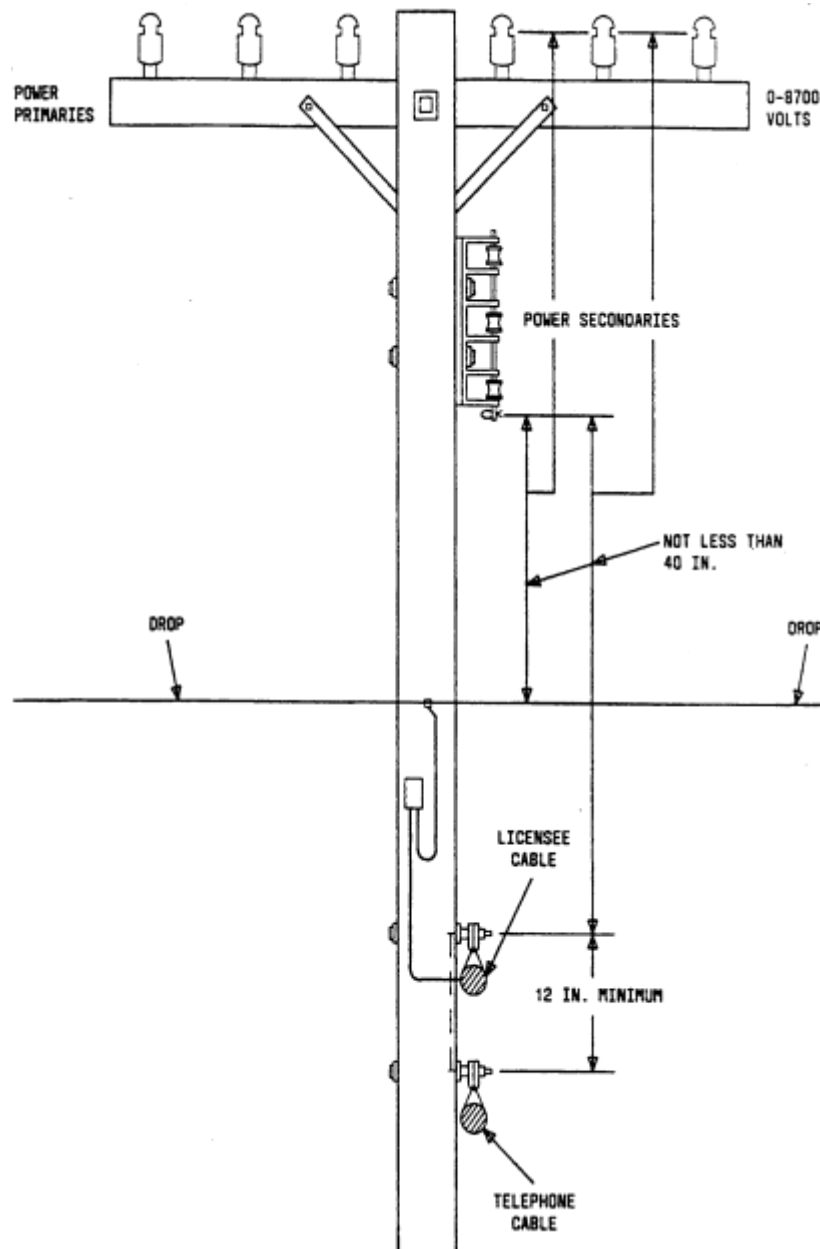
**Table Notes**

- [1] The clearance is 40 inches plus 0.4 inch per kV over 8.7 kV.
- [2] Clearance may be reduced to 30 inches for:
- Grounded supply neutrals (NESC Rule 230E1) or supply cables with a metal sheath (NESC Rule 230C1) supported on a grounded bare messenger
  - Entirely dielectric fiber supply cables (NESC Rule 230F1b)
  - Supply neutral or messenger is bonded to the communications messenger (Chapter 10).
- [3] It is highly desirable that all street-light and traffic-signal brackets be grounded; changes in 2023 NESC to Rule 238 have further reinforced this objective.

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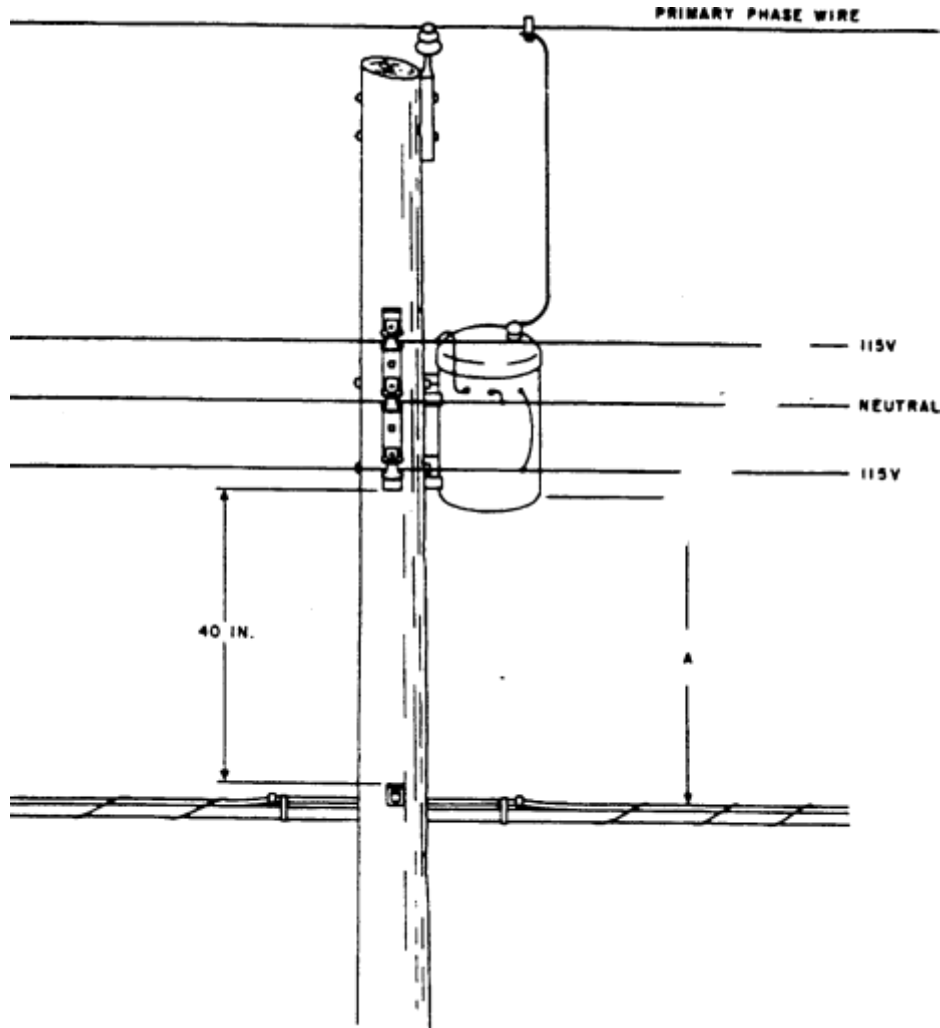
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**Figure 3-3 Clearances on Joint-Use Poles**

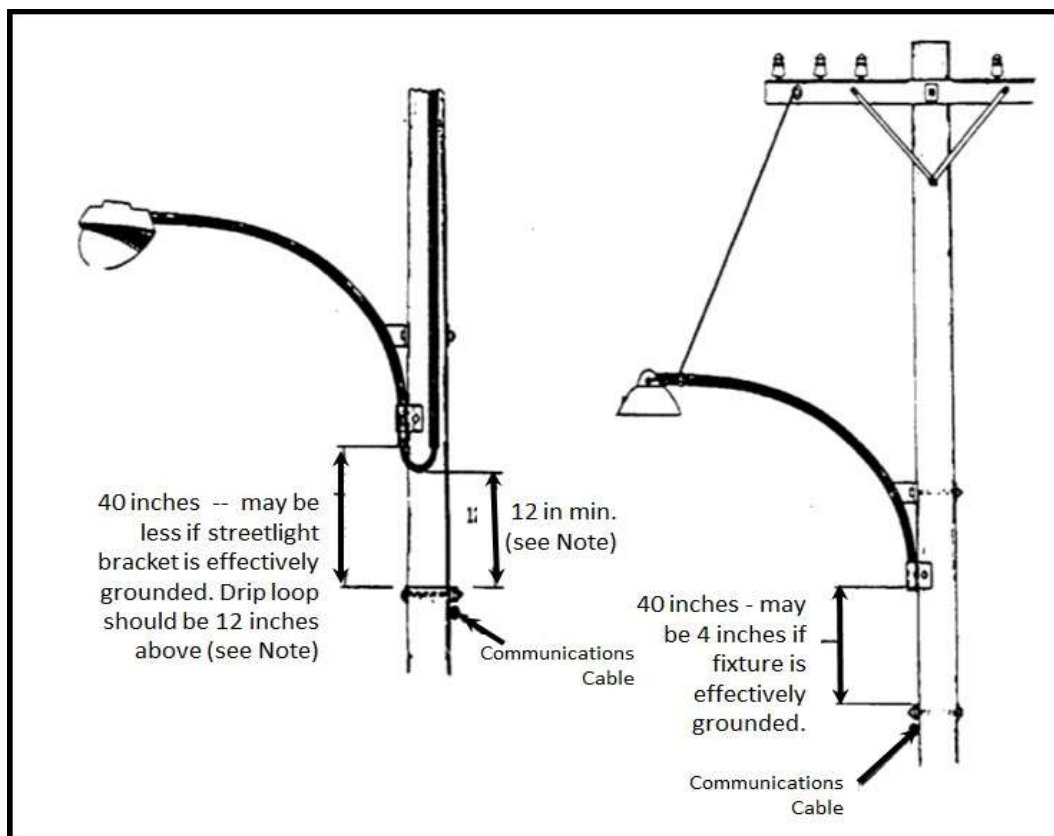
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**Figure-3-4 Clearances Between Power Transformer Voltage Regulator or Capacitor and Communications Wire or Cable**



**Note:** Vertical distance "A" equals 30 inches minimum if the transformer is grounded, and the associated grounded supply neutral (NESC Rule 230E1) or supply cables with a metallic sheath (NESC Rule 230C1) supported on a grounded bare messenger are bonded to communications messengers at regular intervals ([Chapter 10](#)). This bonding needs to be a uniform practice throughout a well-defined area. Otherwise, the vertical clearance dimension shall be a minimum of 40 inches for 8.7 kV or lower voltages. For voltages above 8.7 kV, this distance shall be not less than 40 inches + 0.4 inches for each kV over 8.7 kV.

**Figure 3-5 Clearance Between Streetlight Bracket and Communications Cable**

**Note:** The 12-inch clearance may be reduced to 3 inches if the loop is covered by a suitable non-metallic covering that extends at least 2 inches beyond the loop.

### 3.3.3 Supply Equipment in Communications Space

With the expansion of Smart-Grid devices and intelligent lighting systems within the power grid network, as well as the powering sources for various new wireless and broadband communications devices ([Section 3.3.1](#)), the desire to install more and more pole-mounted monitoring and control cabinets/boxes is occurring on joint-use utility poles and other structures. This increased need for placing more powered devices, some of which are grid-connected devices or supply equipment, in or near traditional communications space requires sufficient separation to minimize interference and reduce congestion. For such equipment to be safely placed near communications, there are appropriate limitations, conditions and specifications needed (e.g., see the last row in [Table 3-1](#) and [Section 14.5](#)).

Traditional CATV power-supply and amplifier equipment, as well as line-powered equipment for broadband communications, follows the rules for “communications equipment” using the clearance and separation rules detailed in Chapters 3 and 14 of this document. This supply-type equipment has been safely installed and operated in or near the communications space for several decades because its electrical voltage, current and power characteristics are well recognized by communications workers who need to routinely install, maintain and repair lines and equipment in the communications zone on the pole. The new wireless communications equipment also falls in a similar category area (see [Chapter 15](#) for a discussion on wireless facilities). The supply equipment for these wireless facilities has been placed by, and is under the ownership and control of, the communications provider (wireline or wireless). This supply equipment is exclusively used to serve and support communications circuits and shall follow the key criteria:

- The conductive portions of its cases and supporting hardware are grounded.
- It operates at low power<sup>4</sup> and at potentials not exceeding those specified for communications lines except for the power supply cable, which operates at less than 150 V.

**Note:** Power is defined as the product of voltage (V) and current (A = amps) or “V.A”. For more detailed discussions on electrical safety and acceptable voltage/current combinations for communications equipment, the reader may refer to GR-1089.

However, in recent times a broader range of supply-type equipment may be found in and around the traditional communications space with operational characteristics that can include:

- Distributed power generation for feeding power into supply conductors at the top of the pole
- Operation at higher ac/dc voltages, e.g.,  $\pm 190$  or 380 V (phase to phase) on span- powering (line-powering) circuits within a communications cables.

The PV panels whose primary function is supplying power to the grid are defined as “electric supply” equipment, while the power circuits designed and maintained to exclusively support communications circuits are defined as “communications equipment” for the safety purposes of the NESC. The circuit is defined by its primary purpose - supply or communications. Each of these power supply-type devices need to be evaluated to assess the electrical hazard risks and physical restraints that it will impose on communications workers who need to climb and work on aerial plant on the pole based on their voltage level and primary use.

### 3.4 Clearance Between Power and Communications Cables on Different Poles

Minimum clearances at crossings of communications wires or cables and power conductors, neutrals, guys, and other communications cables carried on different structures, based on Rule 233 and associated Table 233-1 of the NESC 2023 Edition, are shown in [Table 3-2](#).

**Note:** Historical Note: NESC editions prior to 1990 specified clearance values at 60°F (15°C). In general, such clearances are less strict than the current clearances rules as provided in Table 3-2.

The corresponding clearances in Table 3-2 are measured at the maximum sag condition of the power conductor and, for the communications cable, at the sag under the same ambient temperature as the power conductor. This will occur with the power conductor at either the maximum operating temperature or at 32°F (0°C) with the radial thickness of ice for the loading district involved. The clearances indicated apply when the power facility is above the communications facility.

**Table 3-2 Vertical Clearance at Span Crossing Between Supply and Communications Cables**

**Note:** Conditions -- The upper power supply conductor is at maximum sag and the lower communications cable is at the same ambient temperature as the supply conductor.

| Between Communications Facility<br>and                                   | Vertical Clearance |        | Remarks [Note 3]                     |
|--------------------------------------------------------------------------|--------------------|--------|--------------------------------------|
|                                                                          | Wire and Cable     | Guy    |                                      |
| Shielded or insulated, grounded, supply cables, 0 - 750 V                | 2 feet             | 2 feet | Supply cables meeting NESC 230C      |
| Neutrals associated with systems of 22 kV or less to ground, if grounded | 2 feet             | 2 feet |                                      |
| Open conductors 0 - 750 V                                                | 4 feet             | 4 feet | 2 feet for supply service drop wires |

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| Between Communications Facility<br>and                                                          | Vertical Clearance                                         |                    | Remarks [Note 3]                                                                    |
|-------------------------------------------------------------------------------------------------|------------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------|
|                                                                                                 | Wire and Cable                                             | Guy                |                                                                                     |
| Open conductors and service drops 750 V - 22 kV                                                 | 5 feet<br>[Note 1]                                         | 5 feet<br>[Note 1] |                                                                                     |
| Open conductors over 22 kV                                                                      | [Note 2]                                                   | [Note 2]           | 5 feet + 0.4 in/kV over 22 kV                                                       |
| Neutrals of systems above 22 kV to ground, and any neutral not grounded                         | Same clearance as used for phase wires                     |                    |                                                                                     |
| Supply cables having grounded continuous metallic sheaths                                       | 2 feet                                                     | 2 feet             | Supply cables meeting NESC 230C1                                                    |
| Other power supply cables, including Spacer cables (Figure 3-6) and Triplex cables (Figure 3-7) | Same clearance as for open power wires of the same voltage |                    |                                                                                     |
| Service drops<br>750 V or less (above communications)<br>750 V or less (below communications)   | 2 feet<br>4 feet                                           | 2 feet<br>4 feet   | Locating a power drop beneath a communications cable should be avoided if possible. |
| Guys, span wires, lightning protection wires                                                    | 2 feet                                                     | 2 feet             |                                                                                     |
| Foreign communications cables, wires, and guys                                                  | 2 feet                                                     | 2 feet             |                                                                                     |

- Notes:** [1] Clearance may be reduced to 4 feet where supply conductors of 750 V up to 8.7 kV cross a communications line more than 6 feet horizontally from a communications structure (i.e., utility pole).
- [2] Vertical clearance should be 5 feet + 0.4 in per kV over 22 kV; e.g., a 36 kV line requires a minimum clearance of 5 feet + 0.4 (36-22) feet = 5 + 0.4 x14 = 10.6 feet.
- [3] Communications cable must not pass within 3 feet of other pole.

### 3.5 Clearance Between Power and Communications Conductors Along Span

The required minimum clearances, along the span, between power supply conductors and communications conductors below are shown in Table 3-3. These clearances are based on Rule 235 and associated Table 235-5 of the NESC. Clearances are measured at the maximum sag condition of the power conductor and the communications conductor at the final unloaded sag under the same ambient temperature as at the power conductor.



In general, communications conductors at any point along the span must be no closer to power conductors of less than 50 kV (phase-to-phase) than 75% of the clearance required at the supporting structure (pole), as provided in [Table 3-3](#). Thus, where separation at the pole must be at least 40 inches, a minimum of 30 inches is required at midspan. The minimum separation is increased for higher voltage levels. This clearance is applicable at the closest point of approach, with the power conductor assumed to be at its final sag position including radial thickness of ice as specified for the loading district, or at maximum operating temperature, and the lower communications cable at the same ambient temperature as the supply conductor – i.e., whichever condition produces the greatest required separation distance at the pole.

The separation along the span may be reduced to a minimum of 12 inches for grounded supply neutrals or supply cables with a metal sheath, provided that a 30-inch clearance is maintained at the supports; the supply cable must be supported on a grounded bare messenger, and the supply neutral or messenger bonded to the communications messenger.

Communications service drops may have a vertical clearance of 12 inches from power service drops at any point in the span and at the attachment to the building if the required clearance is maintained at the supporting structure.

**Table 3-3 Minimum Mid-Span and Vertical Clearances (see Figure 3-8)**

| Power Conductor                                                                                                                   | Maximum Voltage | Minimum Clearances Along the Span (See <a href="#">Figure 3-8</a> ) |            | Minimum Clearance at Pole [Note 1] |
|-----------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------------------------------------------|------------|------------------------------------|
|                                                                                                                                   |                 | A                                                                   | B [Note 2] | C                                  |
| Open Conductors, Spacer Cable ( <a href="#">Figure 3-6</a> ), or Triplex/Quadraplex Cable ( <a href="#">Figure 3-7</a> ) [Note 3] | 0 to 750 V      | 30 inches                                                           | N/A        | 40 inches                          |
|                                                                                                                                   | 750 V to 8.7 kV | 30 inches                                                           | $\geq 0$   | 40 inches                          |
|                                                                                                                                   | 8.7 to 50 kV    | 75% of C [Note 4]                                                   | $\geq 0$   | 40 in + 0.4 in per kV over 8.7 kV  |
| Other cables with grounded sheath or messenger, bonded to communications cable [Note 5]                                           | < 50 kV         | 12 inches                                                           | N/A        | 30 inches                          |
| Grounded neutrals, bonded to communications cable [Note 5]                                                                        | < 50 kV         | 12 inches                                                           | N/A        | 30 inches                          |

**Note:** [1] The minimum clearance at poles (“C”) may have to be greater to meet mid-span requirements.

[2] The clearance value “B” is for spans longer than 150 feet and is determined at a conductor temperature of 60°F (15°C), with no wind, and for final unloaded sag. The objective of this clearance “B” requirement is to help ensure that over long spans of power supply lines with voltages above 750 V, the power supply lines

are not permitted to sag below the communications line of sight line.

[3] Includes neutral, if not grounded.

[4]  $75\% \text{ of } C = 75\% \text{ of the minimum clearance at pole ("C") as determined by the formula in the last column of the table.}$

[5] Supply cables or neutrals meeting NESC Rules 230C1 and 230E1, respectively, provided the supply neutral or messenger is bonded to the communications messenger.

**Note:** Clearances are measured at the maximum sag condition of the power conductor and the communications conductor at the final unloaded sag under the same ambient temperature as at the power conductor.

**Figure 3-6 Spacer Cables**

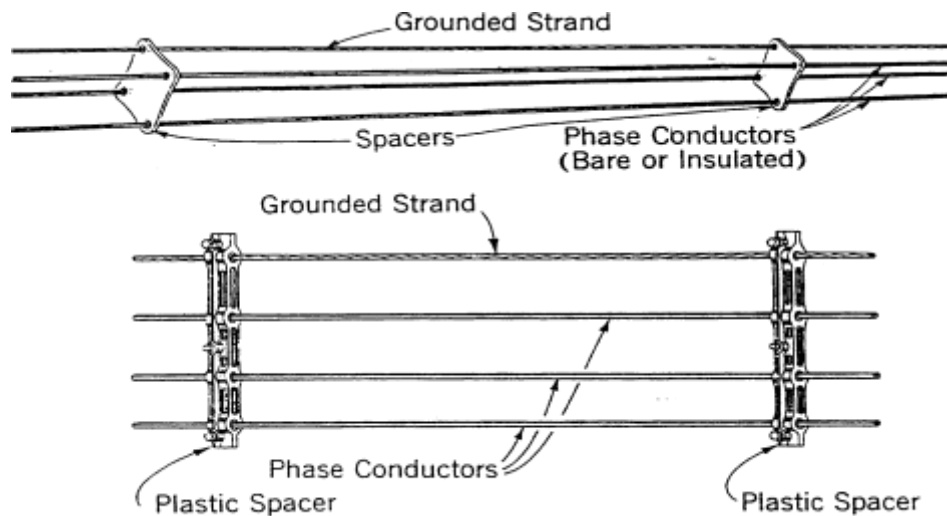
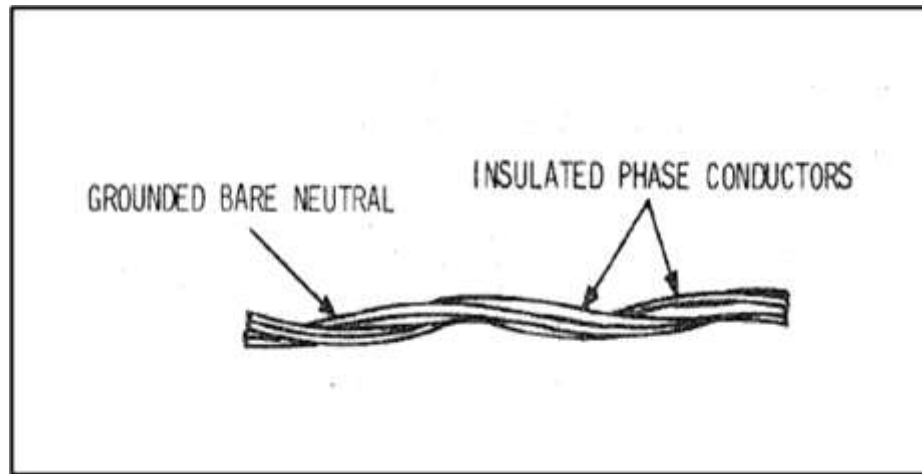
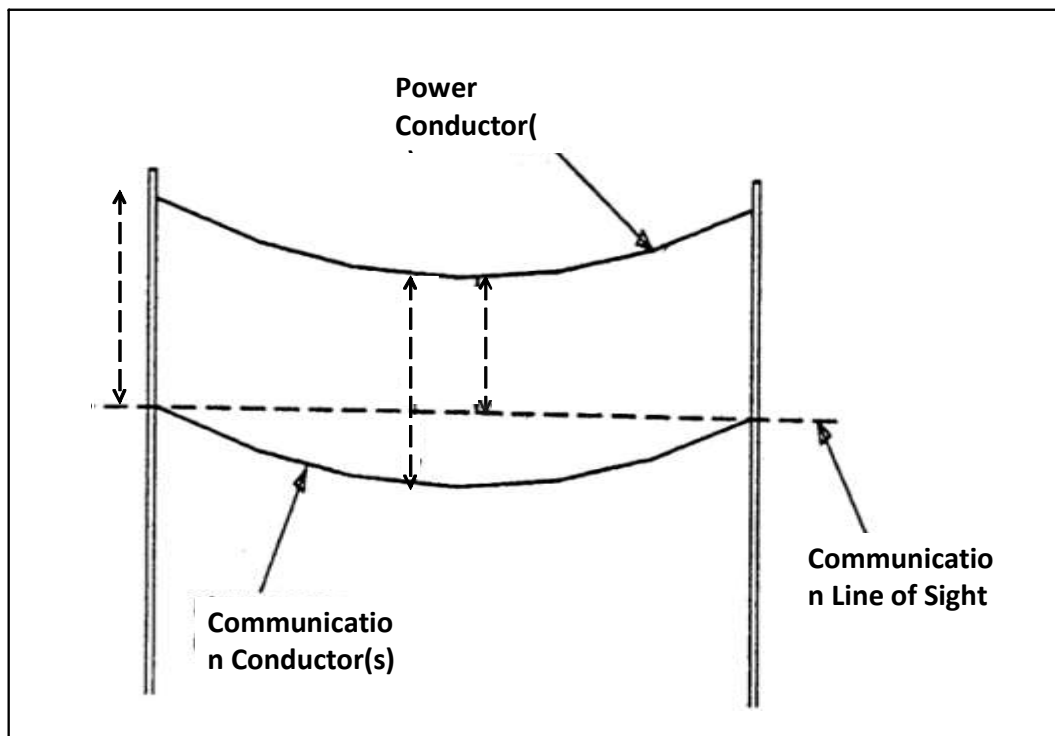


**Figure 3-7 Triplex Power Cable****Figure 3-8 Midspan Clearance**

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### 3.6 Clearances Above Roadways, Rails, and Other Structures

Minimum clearances of communications cables are provided in [Table 3-4](#). The clearances shown in [Table 3-4](#), column 2, represent communications conductor or cable under worst-case sag condition (closest approach); i.e., maximum cable temperature (120°F), or with radial thickness of ice for the loading district involved, and no wind displacement. These clearances are based on Rule 232 and associated Table 232-1 of the NESC. Although the clearance numbers appear significantly different from earlier code editions (pre-1990) because of the different form in which they were expressed, attachment heights are essentially unchanged in the heavy loading district. Thus, the clearance values indicated in column 2 of [Table 3-4](#) must not be applied at the nominal 60°F (15°C), but are intended to be applied under maximum sag conditions. (See [Section 3.1](#) for additional information.)

For convenience, samples of the basic clearance values as provided in the NESC 1987 Edition and also included in [Table 3-4](#), column 3, are provided for possible application to existing installations where the earlier edition (e.g., 1987) may still apply. These 1987 values are shown italicized to emphasize they are not directly applicable to new installations or modifications of installations originally based upon more recent editions (after 1990). The 1987 data is provided here as a historical reference rather than suggested guidance and as an illustration of the alternate methods that may be used for specifying clearances.

**Table 3-4 Vertical Clearances for Communications Cables and Messengers**

| Nature of Surface or Structure Below Insulated Communications Cable | Typical Clearances    |                                 | Remarks                                                                                                                                        |
|---------------------------------------------------------------------|-----------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                     | 2023 Code<br>[Note 1] | 1987 Code<br>[Note 2]           | Notes on NESC 2017 Clearances Regarding Tables 232-1 and 234-1 and their footnotes                                                             |
|                                                                     | All Loading Areas     | <i>Not Generally Applicable</i> |                                                                                                                                                |
| <u>Crossing above</u>                                               |                       |                                 |                                                                                                                                                |
| • Railroad Tracks                                                   | 23.5 feet<br>[Note 3] | <i>25 feet</i>                  | For special railways using cars less than 22 feet high, see NESC Table 232-1                                                                   |
| • Public Roads                                                      | 15.5 feet             | <i>18 feet</i>                  | Subject to truck (> 8 feet high) traffic                                                                                                       |
| • Public Alleys                                                     | 15.0 feet             |                                 | Not subject to truck traffic                                                                                                                   |
| • Nonresidential Driveways/Parking Lots                             | 15.5 feet             | <i>18 feet</i>                  | 15.0 feet if not subject to truck traffic                                                                                                      |
| • Residential Driveways                                             | 15.5 feet             | <i>10 feet</i>                  | The 2017 NESC permits a reduced clearance of 11.5 feet over driveways where truck traffic is unlikely [Note 5].                                |
| • Walks and Lanes                                                   | 9.5 feet              | <i>8 feet</i>                   | Clearance permitted to be reduced to 8 feet if area is not subject to any traffic, riders on horseback, or otherwise having restricted access. |

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|                                                                                        |                              |                |                                                                                                                                                   |
|----------------------------------------------------------------------------------------|------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| • Flat Roof Buildings                                                                  | 10.5 feet                    |                | Areas readily accessible to pedestrians                                                                                                           |
| • Peak Roof Buildings                                                                  | 3.0 feet                     | <i>3 feet</i>  | Not readily accessible to pedestrians                                                                                                             |
| • Billboards, Signs                                                                    | 3.0 feet                     |                | Horizontal and Vertical                                                                                                                           |
| • Waterways - 1                                                                        | 14.0 feet                    |                | Not suitable for sailboating                                                                                                                      |
| • Waterways - 2                                                                        | 17.5 feet<br>to<br>42.5 feet |                | Function of water area size and location of boat ramp/rigging areas. See rows 7 and 8 of NESC Table 232-1 or the proper administrative authority. |
| <u>Paralleling (Alongside)</u>                                                         |                              |                |                                                                                                                                                   |
| • Urban Roads [Note 4]                                                                 | 15.5 feet                    | <i>17 feet</i> | 15 feet if in back of vehicular deterrents such as curbs or guardrails                                                                            |
| • Rural districts and areas where farms are likely and light traffic is usual [Note 4] |                              |                |                                                                                                                                                   |
| behind<br>obstacle<br><br>exposed (not behind<br>obstacle)                             | 9.5 feet                     | <i>14 feet</i> | Unlikely to have vehicles passing under the line. Obstacles include ditches, fences, embankments<br>(See footnotes 10, 12 to Table 232-1).        |
|                                                                                        | 13.0 feet                    | <i>14 feet</i> |                                                                                                                                                   |
|                                                                                        | 15.5 feet                    | <i>17 feet</i> | 15 feet if behind vehicular deterrents (e.g., curbs) or not subject to truck traffic                                                              |
| • Public Alleys                                                                        |                              |                |                                                                                                                                                   |

**Table Notes:•**

- [1] Represents clearances that are usually applicable but are often modified by specific conditions covered by Tables 232-1 or 234-1 of the NESC with nuances described in the numerous footnotes.
- [2] NESC 1987 Edition basic clearances under nominal 60°F (15°C) conditions, no wind, to be adjusted (increased) for relatively long spans. These values are shown italicized to emphasize they are for reference only and not applicable to new installations or plant modifications.
- [3] Minimum size messenger strand required for crossing is 6 M strand.
- [4] NESC no longer denotes these regular and light traffic areas as “urban” and “rural” zones.
- [5] Footnote 7 of NESC Table 232-1 permits 11.5 ft clearance for the service drop communications cables “where vehicles exceeding 8 ft in height are not normally encountered nor reasonably anticipated...” Such a provision is difficult to definitively determine for any residential driveway given the possible needs for truck deliveries to residences and commercial buildings combined with the possible larger recreational vehicles being used. Furthermore the type of activities under a service drop and along driveways change as the use and roles of properties and buildings change over time. The objective should remain to achieve the 15.5 ground clearance over any driveway where possible and practical. The use of service masts or other means (see Section 3.10) to raise the cable span should be considered where low hanging communications service drops will result from connections to a low building or from a building being located significantly down grade from the service pole.

The lowest clearances are based on a reference height of 8 feet considered the maximum reach of a person. The 8 feet value is also used to define if structures are not readily climbable that is a realistic and practical value.

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However, the permitted reductions in clearances (via footnotes 7/8 of NESC Table 232-1) over residential driveways to a height of 10 and 10.5 ft are no longer practical given the larger RV vehicles (usually 8.5 to 9.5 ft in height) and especially delivery vehicles (12 feet) that are currently in use. Delivery vehicles, transit vans and recreational vehicles up to at least 10 to 11 feet in height are likely to be encountered in most driveways.

Therefore, assuming the 8 feet maximum vehicle height is no longer a useful criterion, the minimum design ground clearance over a driveway for a communication line (drop) should be higher at 12 feet (communications) and 13.5 to 14 feet (power).

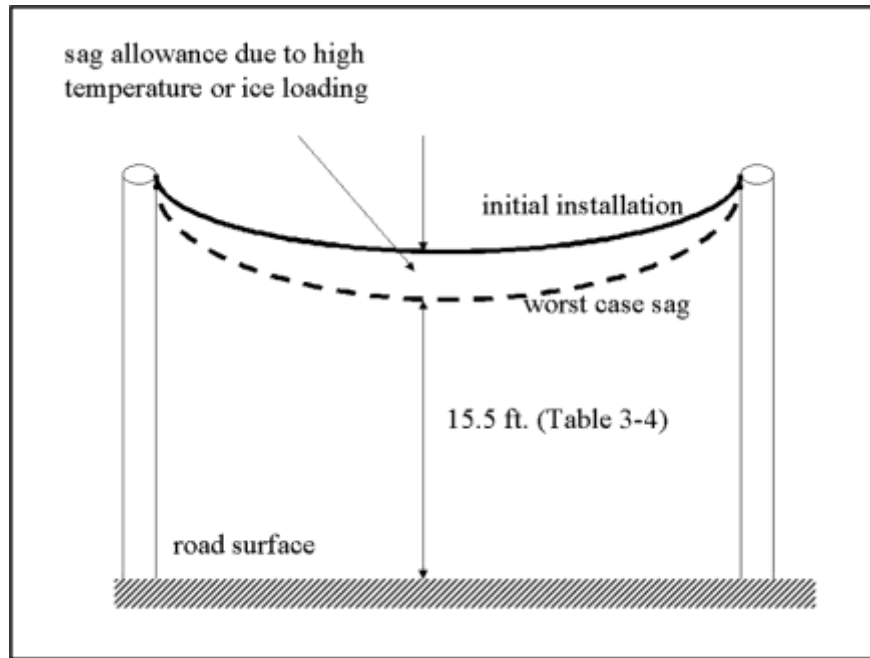
### 3.6.1 Clearance Example

Consider an example of a communications cable (supported on messenger) suspended over a public road, as illustrated in [Figure 3-10](#). [Table 3-4](#) indicates that the minimum vertical clearance (the closest distance from the ground to the span), at worst case, must be 15.5 feet. Thus, at initial installation, sufficient additional separation must be provided to account for subsequent cable sag under temperature (120°F) or ice loading, whichever represents the most severe sag condition for the geographic area of interest. [Table 3-5](#) provides the relevant ice loads (and temperature) to be considered. Ice is assumed to weigh 57 lb/ft<sup>3</sup>. Figure 250-1 of the NESC, included in [Chapter 13](#) of this manual, shows the districts where these loadings apply. Since there is no radial ice (0 inches) specified for the Light Loading District, the 120°F temperature condition will result in the most severe sagging condition in that area. In other areas (e.g., Heavy Loading District), the ice loading would typically predominate.

**Table 3-5 Ice Loading Conditions**

| Loading Districts [Note 1] |           |        |
|----------------------------|-----------|--------|
| Heavy                      | Medium    | Light  |
| 0.50 inch                  | 0.25 inch | 0 inch |
| 32°F                       | 32°F      | 32°F   |

**Note:** See [Chapter 13](#) of this manual for corresponding geographic areas.

**Figure 3-9 Vertical Clearance Over Public Road**

Thus, the height at which a cable initially is to be installed above a surface such as a street, pedestrian path, navigable waterway, etc., is determined as follows:

Minimum Vertical Clearance from Table 3-4

plus (+)

Sag Allowance Due to High Temperature or Ice

Loading equals (=)

Total (Installed) Vertical Height Over Surface

Changes in sag depend on ice loading, conductor temperature, span length, cable diameter and weight, initial installed tension, and the mechanical (elongation) characteristics of the cables or messengers. In general, it will therefore be necessary to contact the communications company (or the licensee) for sag information on its cables and messengers. For the purposes of the present illustration, if it is determined that the sag increase from the conditions at initial installation (e.g., nominal 60°F) is 2.5 feet (e.g., due to the 1/2 inch ice loading of the Heavy Loading District), then the following calculation results:

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$$\begin{array}{r} 15.5 \text{ feet} \\ + \text{ 2.5 feet} \\ \hline = 18.0 \text{ feet Total} \end{array}$$

Thus, if the cable is installed at the assumed nominal 60°F condition, then an 18-foot clearance above the road must be provided initially. The additional 2.5 feet represents the allowance for subsequent sag increase under the ice loading for that area. It should be noted that for this example, the NESC 1987 Edition specifies the same 18-foot clearance as calculated above. In other cases, however, the results may be somewhat different.

Also, it should be noted that in some jurisdictions the controlling authority (State PUC/PSC or Federal Highway authority or municipal ordinances) may require greater clearances across certain roadways that are not stipulated in the current NESC.

To avoid doing sag calculations for every case, some companies will set clearances significantly larger than the [Table 3-4](#) values. For example, some railway companies require a 29-foot minimum for communications cables crossing railroad tracks to take into account all likely sag effects and future-proof the installation against changes in ground level and future increases in railroad car heights. Such conservative approaches will help achieve adequate clearances and reduce future pole remediation but can lead to requiring taller poles than necessary in some cases and thereby increase the initial capital cost of the project.

### 3.7 Communications Antennas

Rule 235I was introduced in the NESC 2002 Edition to specify clearances between communications antennas installed in the power supply space and supply line conductors.

As the technology and equipment evolved, harmonizing changes were made in 2007, 2012 and 2017 code cycles for Rule 235I and related sections of Rules 238 and 239 that apply to antennas and their associated equipment and connecting cables. In the 2023 NESC, clearances for antennas and wireless associated equipment were moved and consolidated under Rule 238F. All these code revisions were for clarification rather than any fundamental alteration to required clearance and separation values. As poles, buildings and structures become more congested with wireless, broadband and Smart-Grid devices, and associated equipment, it will become even more critical that proper clearances and separation be maintained around the antenna, its associated equipment and the interconnecting cables associated with these devices. The current NESC rules when properly applied should provide adequate working and climbing space for the technician as well as the physical protection and separation distances to help ensure reliable operation of the devices.

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The initial preference was to have antennas placed as high as possible to maximize coverage area; i.e., placement in or above the power space and power lines.

However, current trends to support Distributed Antenna Systems (DASs) and 5G/6G networks will require a much greater density of smaller antennas deployed across any given geographic area. These antennas and their associated equipment are now being located lower down on the supporting pole or structure, in and around the communications space as well as attached to strands/messengers in midspan. The business drivers for such lower down placement include the space limitations on poles, increased ease-of-access and lower initial installation, capital and construction costs.

This section provides some general basic clearance information and safety precautions for wireless facilities. The clearance issues for wireless facilities along with associated RF exposure concerns and other separation issues are discussed in more detail in Chapter 15. In addition, a recent IEEE Guide has been developed – IEEE P2939 Guide - *Guide for Joint Use of Utility Poles with Wireline and/or Wireless Facilities* – that provides details on the various choices for antenna placements and clearances as well as guidance on the recommended process for attachment application to existing joint-use structures.

### 3.7.1 Basic Clearances

Table 3-6 provides minimum separation distances, in any direction, of supply cables from antennas operated at 0 - 750 V. The separation between an equipment case supporting a communications antenna and supply lines may be reduced to a 1-inch minimum for supply circuits of 0 - 750 V, or shielded or insulated supply cables (NESC Rule 230C) supported on a grounded bare messenger. Other network configurations may require greater clearances.

Additional rules associated with the clearance between a supply line conductor and a communications cable attached to a communications antenna are provided in Rule 239 of the NESC.

**Table 3-6 Clearance from Supply Line Conductors on the Same Structure in Any Direction from Communications Antennas (0 - 750 V) Mounted in the Power Supply Space**

| Supply Line Type<br>(Voltage Is Phase-to-Phase) | Clearance in Any Direction             |
|-------------------------------------------------|----------------------------------------|
| 0 to 750 V                                      | 3 inches                               |
| 751 V to 8.7 kV                                 | 6 inches                               |
| 8.71 kV to 50 kV                                | 6 inches + 0.4 inch per kV over 8.7 kV |
| 50.1 kV to 814 kV                               | 23 inches + 0.4 inch per kV over 50 kV |

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### 3.7.2 Placement Concerns for Antenna and Associated Equipment

Communications antennas that are deployed at the top of the poles above power supply plant may not be easily accessible by the antenna owner or wireless service operator. When communications antennas are deployed at the top of the pole, they shall be installed and maintained only by personnel authorized and qualified to work in that electric supply space, in accordance with the applicable work rules of NESC, Sections 42 and 44.

There are additional mechanical and performance concerns with installations at the top of the pole, including the possible premature splitting or weakening of the pole top. For this reason, the top 6 inches is usually designated as “unusable space” in Joint-Use Agreements (JUAs), and the bolts and screws of attachment hardware for antenna and pole top extensions should not be placed into the top 12 inches of the pole. Pole top masts are often used to place the antenna well above the supply lines and to help provide a more secure attachment to the pole.

Whenever height or weight is added to a pole, due care and attention should be paid to the loading calculations. In general, the antennas and associated supporting boxes/cabinets do not add substantial weight; however, the profile of the wireless equipment may affect wind profile and potential ice loading on the structure. The strength of the support elements for the wireless plant, including cross-arms, brackets, braces and the other attachment hardware, needs to meet the appropriate construction grade.

While the antenna itself may be located in or above the supply space, other associated equipment such as control boxes, meters or connections are typically located lower down on the pole in communications or neutral space. Since the interconnection cables often pass from supply space, through the Communications Workers Safety Zone (CWSZ) into communications space, it is important to ensure that adequate physical protection and electrical isolation is maintained.

The mechanical and electrical protection for safeguarding the workers and the interconnection cables is accomplished with ducts and conduits that physically cover and guard the cables as well as electrically insulating the cable connections. Clearances from adjacent power and communications lines also need to be maintained where the cables exit the conduit and enter antenna or equipment closure. Particular attention is needed to avoid the drip loops or stress relaxation loops of the cable becoming a hazard through contact or close approach with nearby energized lines or equipment.

Antennas are also being located in the communications space either pole-mounted directly or on side arm or cross arms. The clearances in [Table 3-6](#) and concerns about protecting interconnection cables equally apply to these installations. Their lower position on the pole requires attention to additional factors including:

- Their clearance above ground level for these devices needs to meet the NESC Rule 232 clearances from [Table 3-4](#).

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- An increased possibility of interfering with available climbing space and working space required under NESC Rules 236 and 237.
- Concerns about exposure to RF radiation from wireless transmitter equipment and how to manage the RF exposure of any workers who need to access plant on, or near, the joint-use supporting structures.

For other wireless locations such as mounting to a wall, in a belfry, or on a roof top of a building, similar issues need to be assessed and considered for the construction and installation at the location to help ensure there is:

- Safe working space for access and maintenance – including roof access and adequate roof loading capacity to carry facility equipment and closures
- Sufficient clearances and/or guarding from other equipment in the vicinity – could be power or communications equipment, although on roof tops this is more likely to also include:
  - HVAC handling equipment – filtration, cooling towers and exhaust stacks
  - Elevator mechanical rooms that have powerful generators and engines
  - Water storage tanks for some high-rise buildings to maintain sufficient pressure and to support fire suppression systems (sprinklers) systems.

The clearances and guarding can be for protection/isolation from electrical influences, mechanical/vibrational stresses or from additional particulate/ pollution loadings from operating HVAC equipment.

- Sufficiently strong attachment hardware and anchoring points to secure the facility under expected weather conditions that could include heavy rain, storms, high winds and freezing conditions as well as earthquake and possible operational vibrational stresses from neighboring roof top equipment.
  - For WiTF (Wireless Transceiver Facilities) placed on rooftops, the roof needs to be assessed to help ensure that suitable and secure attachment points are available and that the roof and its underlying support can withstand any expected loads (weight of equipment and technicians needing access plus additional forces from effects of storm (wind/rain).

No matter where the WiTF and associated equipment/closures are located, the items located outside of a building envelope will need to be bonded into the grounding schemes used to provide electrical protection (lightning protection and power fault conditions) for the wireless equipment and to help prevent outside surges from entering the building and into customer premises equipment.

### 3.7.3 Clearances for Antenna Structures, Cables, and Associated Closures

Any cable (antenna cable or power supply cable) coming from, or going to, an antenna structure shall travel down the pole in an insulating conduit (NESC Rule 239). The antenna structure or closure associated with an antenna shall be grounded to the power ground (MGN).

Any cable or connection between the antenna structure and the communications plant in the telecom space shall pass through a weathertight closure/box/cabinet mounted so that

- The bottom of the closure is at least 12 inches above the highest telecom cable, and the top of the closure shall be at least 40 inches below the lowest power supply cable, or
- The top of the closure shall be at least 30 inches below the lowest telecom cable and the bottom of the closure shall be at least 8 feet above ground level
- The closure and interconnections it contains shall be grounded to the power neutral (MGN)
- All cable or connections to the closure shall be contained inside insulating conduits.

Any antenna structure mounted above the communications space shall be at least 12 inches above the highest telecom cable, and the top of the antenna structure shall be at least 40 inches below the lowest power supply cable. If this is not possible, then the antenna structure needs to be mounted in the power space by trained supply personnel.

### 3.7.4 Radiation Emissions

Based on NESC Rule 420Q and 220E, the antenna owner or operator should supply and post the information on radiation (RF) emissions for a communications antenna.

Informational or warning labels as appropriate shall be on poles with emitting wireless equipment (antennas), and RF safety programs (RFSP) shall be in place with all joint-users of the pole. When working in the vicinity of communications antennas, workers shall not be exposed to radiation levels that exceed those set forth by the regulatory authority having jurisdiction.

The reader shall refer to [Chapter 15](#) for detailed discussions on the required elements of the RFSP, pole marking/labeling and safety clearances/separations required between wireless facilities and other equipment on the structure (communications and power).

## 3.8 Clearance of Supporting Structures (Poles) from Other Objects

Poles, supporting arms, anchor guys, and associated equipment shall be located a sufficient distance from fire hydrants, streets, roads, highways, and

railroad tracks to avoid contact with ordinary vehicles using and located in the travel way. The general guidelines include:

- Fire hydrants and traffic light posts – minimum of 4 feet.

**Note:** Recent changes to NESC Rule 231-A has permitted a reduction to 3 feet. *Ericsson - NIS considers that distances less than 4 feet represent a safety hazard and recommends that no hydrant be located closer than 4 feet to a pole.* Any communications company who maintains a plant in a fire district where fire-hydrant-to-pole clearances are less than 4 feet should ensure that full responsibility for exemption from the NESC is placed on the correct authority (i.e., the local fire department or the local municipality or local government).

- Roadways – facilities (poles) located 5 feet from travel lane or behind the curb by 2 feet where practical.

**Note:** *The minimum 6-inch distance behind the curb has been deleted from the 2017 NESC. Ericsson - NIS recommends that a pole should be placed well back from the traffic lanes and well behind the curb to help reduce the probability of impacts from vehicles that leave the normal traffic lanes. (See [Section 3.8.1](#) below.)*

- Railroad tracks – Facilities should be not less than 12 feet from the nearest track rail.

All the above circumstances involve various parties that need to consult together to maintain a safe working and public space to avoid structure conflicts.

### 3.8.1 Pole Placement Along Roadways

There are safety rules and design recommendations associated with pole setback distances from roadways and use of reflector markers to alert drivers as to presence of obstacles near the roadway. The 2023 NESC code Rule 231B states:

*“...Where there are curbs: supporting structures, support arms, anchor guys, braces, and equipment attached thereto, up to 4.6 m (15 feet) above the road surface shall be located a sufficient distance behind the curbs to avoid contact by ordinary vehicles using and located on the traveled way.....”*

The specific guideline of a minimum of 6 inches behind the curbs was dropped in 2017 code because it was not considered to provide any real safety benefit versus the pole being directly behind the curb. From a design perspective, it would be useful to have guidance on objective clearance of poles from the roadway and the use of reflector strips in cases where the full clearance cannot be achieved. The factors that determine a desired clearance zone along the roadway or highway include:

- **Roadway Class** as defined by the DOT for the area – The roadway class

defines expected traffic volume and, more importantly, the speed that helps determine sight and stopping distances which, in turn, helps define a desirable clear zone from the roadway for a vehicle to recover from accidental action that takes the vehicle outside of the normal traffic lane.

- **Roadway configurations** – Includes bends, curves, merges, median strips, intersections and secondary impact zones (e.g., most accidents happen within 50 feet of intersections).
- **Adjacent Surroundings** – Shoulders and parking lanes can provide some additional protection and clearance for a pole from the ordinary traffic lanes where vehicles are expected to remain. Concrete finished curbs, guardrails, and ditches/mounds along a roadway all help provide additional physical protection and barriers between the utility pole and a direct impact from a vehicle.
- **Experience** – Past traffic accident, pole damage and injury analysis data helps to identify particular highways or intersections that require increased protection, such as placing poles at greater distances, adding reflectors, or adding concrete barrier posts.
- **Clear Zone distances from travel lanes** – Guidance from the traffic industry can be found in DOT manuals and AASHTO design guides:
  - 5 to 10 feet for low-volume traffic at slower speeds (30-40 mph)
  - 10 feet baseline for low-volume traffic at higher speeds (60 mph)
  - 10-15 feet for medium volume traffic at higher speeds (60 mph)
  - 20-25 feet for higher volume traffic defined as 2000-6000 ADT (Average Daily Traffic count) at higher speeds (60 mph).

The above AASHTO values are from highways and rural roads where sufficient clear zones are readily available. Real world practical horizontal distances from traffic lane in roadway to utility pole will need to consider all the factors noted above along with the applicable DOT rules that are enforced and used for that area. When we add in consideration of curbing and road shoulders, we find that other objective distances are useful minimum guidelines for urban environments, such as:

- 1.5 feet behind the face of a curb – for urban arterial streets with curb and no shoulder
- 2.0 feet behind the face of a curb – for urban arterial streets with curb and a parking lane to enable a car door to be opened easily
- 5.0 feet from a curb to avoid relocation costs and problems associated with future road-widening projects
- 5.0 feet from a travel lane – AASHTO guideline with a 10 feet objective if practical to attain
- 10 feet from a travel lane – for urban arterial streets without the curb and without a shoulder.

- 30 feet clearance – some DOTs have required a pole to be placed at the edge of the Right-of-Way (ROW) if one cannot obtain at least 30 feet of clearance from the traffic lane.

The design guidance on pole clearance from the travel lane and use of reflector strips needs to consider various transportation and safety guidelines, including AASHTO, State DOTs, FHA and operational imperatives. Pole clearance from a traffic lane should be at least 5 or 10 feet, with additional clearance if practical and required by traffic volume, speed, or roadway configuration. As a general design guideline or objective, one should attain 10 feet of horizontal clearance from a travel lane on the road or highway, with an objective for 20-30 feet from high traffic areas or where high speeds (> 50 mph) are expected. Greater clearances, use of reflective markers, and/or the addition of protective guards (rails/posts) are advisable for areas of particular concern, such as on

- Outside of sharp curves and bends
- Medians - poles should not be placed on medians or traffic islands.

Maximum clearance from the traffic lanes should be attained based on the available width of the ROW, and on necessary clearances from buildings, structures, and private property within and on the other side of the ROW. These principles need to be adjusted for the local conditions where ROWs and easements in urban environments are often greatly restricted by available space and the location of the pole.

### 3.8.2 Reflector Markers and Strips

Where it is not practical to place the pole at these objective distances from the traffic lanes, the use of reflector markers and strips can reduce accidents, injury and pole damage. The selection of which pole on which to use reflectors is best based on what the attentive driver can see when driving in a normal traffic lane. A pole 20 feet from the roadway should not be in a driver's line of sight while traveling in a normal lane. Utility poles located behind guard rails can usually rely on the reflectivity of the guardrail to provide sufficient visual warning.

The appropriate use of reflector markers or strips on the pole to help prevent impacts and alert drivers to the proper travel lanes would seem to be better reserved for incidents where:

- Significant curves, bends and road direction changes place poles in direct eyesight of drivers in normal traffic lanes
- Utility poles are within 1 foot of a curb of a road (travel way) without a shoulder
- Significant curves (e.g., more than 2 degrees change over 100 feet) or other road shape changes occur, utility poles within 6 feet of the travel lane on the outside curve should have reflective markers

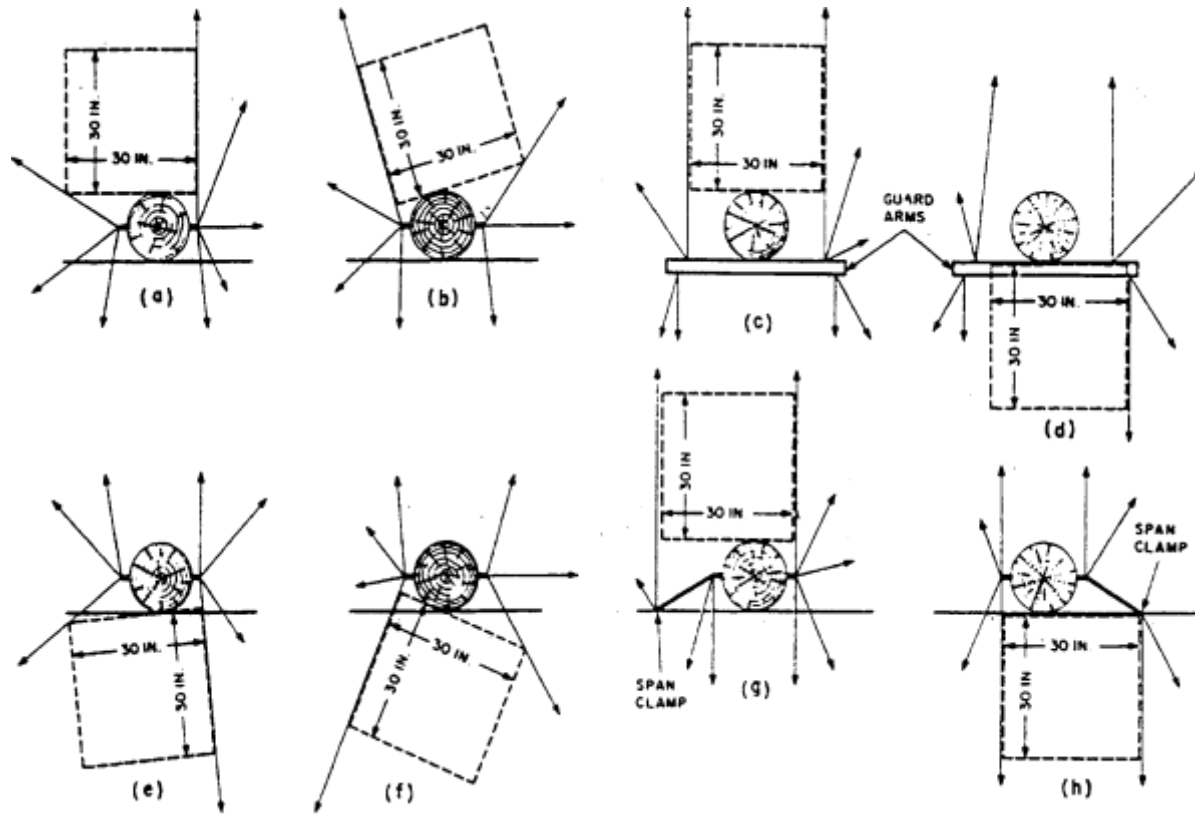
- Utility poles located behind guard rails can usually rely on the reflectivity of the guardrail to provide sufficient visual warning.

### 3.9 Climbing Space

In addition to the clearances covered in [Section 3.2](#) through [Section 3.7](#), proper climbing space must be maintained. Climbing space is an unobstructed vertical space along the side of a pole. In general, it consists of an imaginary box 30 inches square, extending at least 40 inches above the highest communications cable or other facility, and 40 inches below the lowest communications cable or other facility. [Figure 3-10](#) illustrates the maintenance of the 30-inch climbing space where potentially interfering service drops are present. In [Figure 3-10 \(g\)](#) and [Figure 3-10 \(h\)](#), this is accomplished by using span clamps attached to the strand supporting the cable to redirect the drops.

The longitudinal cable runs are not considered as obstructing the climbing space (as per NESC Rule 236G) if their location, size and quantity permit qualified workers to climb past them. However, in some urban environments or alleyways, the combination of the number of attached services leads to “boxed” poles, with distribution lines attached to both sides of the pole and multiple drop and service cables filling the aerial space around the pole. The result can be limited accessible pole or working space for additional facilities, as well as difficulties in avoiding damage to cables while climbing. In such circumstances, the use of aerial lifts or ladders may be the preferable means to access and maintain communications plant on such poles.



**Figure 3-10 Climbing Space Where Drop Wires Are Present**

### 3.10 Service Drop Clearances and Separations

Recommendations for service drop clearances and separations are based on review of industry experience, Telcordia (Bellcore) Recommended Practice BR-627-610-205, *Block and Building Cable Placing*, Issue 3 from 1990; the current editions (2023) of the NESC; the NEC code; and design and practice information provided by service providers.

The basic clearances and reference separations for the service drop communications cables are as follows:

- Ground clearances – see [Section 3.6](#) and [Table 3-4](#), above, for minimum clearances.
  - See [Section 3.10.1](#) for a discussion of service masts to increase ground clearances, if necessary

- Minimum separations from power cables -
  - 40 inches at the pole (see [Section 3.3.2](#))
  - 12 inches across the span between the pole and building attachment
  - 12 inches at the building attachment point.

**Note:** The NESC language in NESC Rule 235C.1.d-exception 3 covering separation between electric and communications service drop between pole and house uses the phrase "... at any point in the span." The span is considered to begin at the pole and end at the building attachment point.

- 4 inches along building wall (2 inches if power cable is protected or covered to provide an insulating barrier, e.g., conduit, raceway, or other side of a wall)

**Note:** A wall between the cables would constitute such an insulating barrier. If accidental contact is possible, then some additional insulating or separation barrier is needed. From NEC Article 230.50 ("Protection *Against Physical Damage*"), one can reasonably infer that some protective conduit should always be used for this power service drop plant.

- 2 inches inside the building (no specified distance if power cable is protected or covered, e.g., conduit or on other side of wall).

For the situations where (a) long drop spans to building, and (b) lengthy horizontal runs along outside building wall are needed, then baseline guidelines and preferences would be:

1. The power conductors/cable should be either (a) attached to power masts so that the power conductors are above the roof line, or (b) attached to the wall above the topmost windows, but below the roof line. A possible arrangement with the power cable up above the windows, and the communications cables far below the windows, is possible to help maintain separation.
2. The power lines attached to the building should be protected and covered, i.e., in a conduit.
3. The power conductors should be
  - kept away from any unguarded windows and awnings, or
  - kept well above (>10 feet) any readily accessible porches, or
  - not run under awnings.
4. The communications cables attached to the wall should be mounted at least 12 inches from the power conductors. You can get them closer if either the power cables or the telecom cables are protected inside conduit.

5. The cable runs that cross downspouts and other vertical conduits are a concern. The clearances from these other building components are to maintain
  - 6 feet from any lightning protection system (wires from roof to a ground rod)
  - 2 inches from down spouts using standoff brackets. The appropriate stand-off brackets and support hardware need to be used to keep the conductors at required separation from each other and the wall surface.

Therefore, in general, communications cables can be as close as 4 inches below the power cable along the side of the building from an electrical safety standpoint.

However, larger separations (12 inches) are preferred to allow adequate working and access space for a communications technician to work on those cables with the supply cables so close unless the power was turned off.

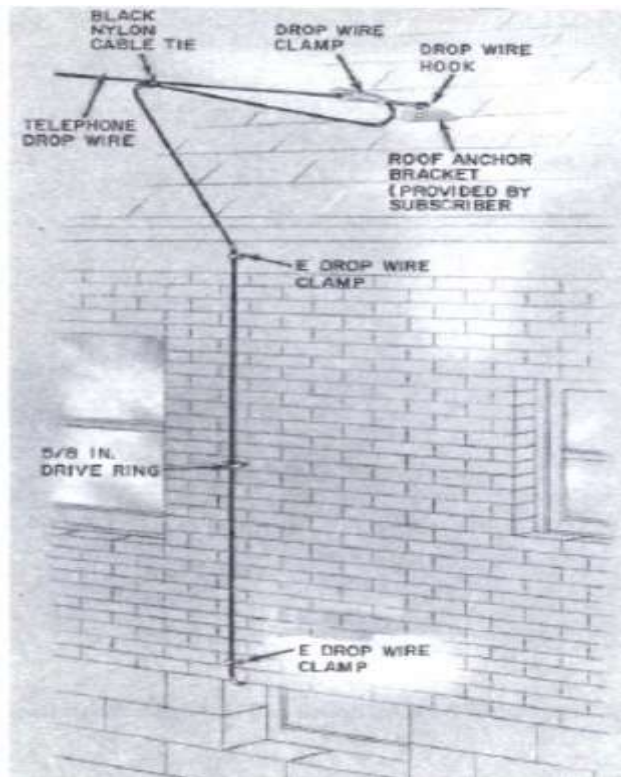
### 3.10.1 Service Masts

Service masts are used for low-lying buildings where the necessary ground clearances of the service drops cannot be easily attained. One should consider attaching to a different location on the building if possible to avoid driveways and pedestrian ways and thereby permit lower ground clearances to be used in mid span. One can also review options for allowable stringing tensions to reduce sag for the drop by pulling the drop cable tighter while remaining within safe limits of the cable strength and attachment hardware capability.

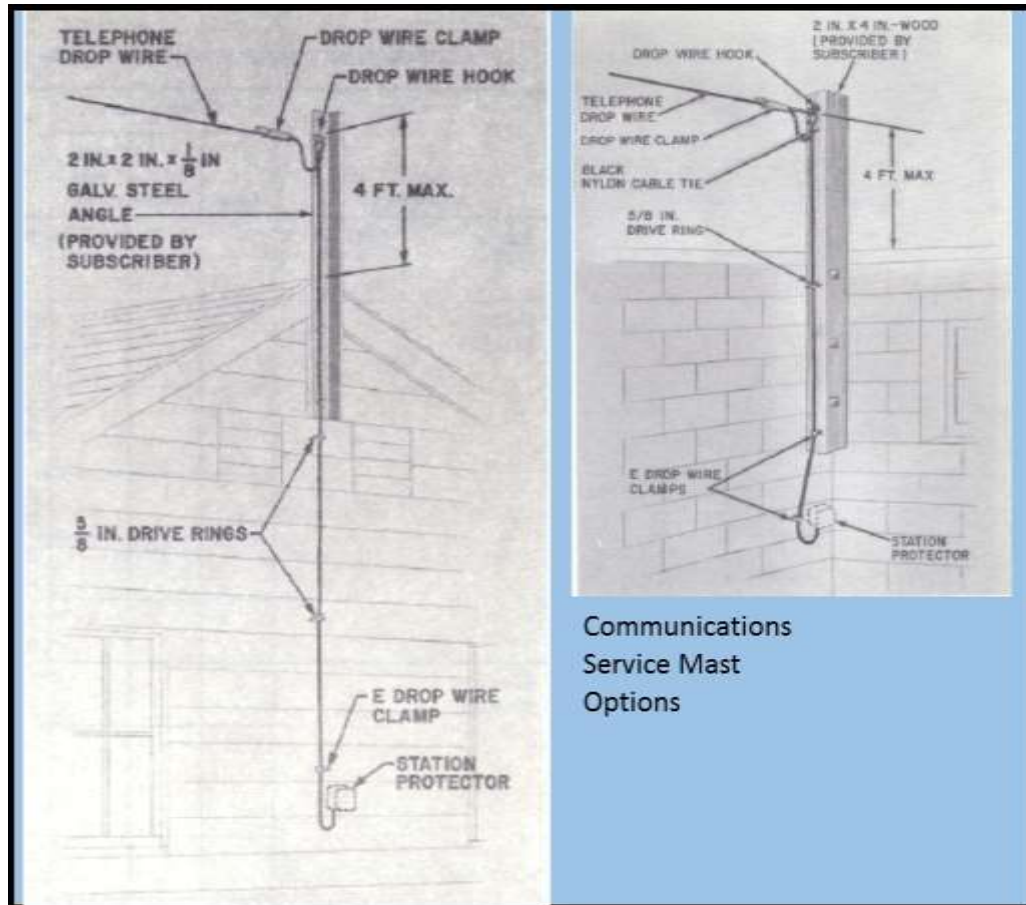
**Note:** The historical Bell System Practice document for service masts was BSP 462-350-213, *Drop and Block Wiring - Fastening and Equipping Drop Wire Runs to Buildings*.

If there is no practical method to get the necessary height of attachment from standard connection to the wall of the building, then one has several options including:

- **Use a buried service drop.**
- **Attach to the power service mast** at least 12 inches below the lowest power conductor – This is not usually desirable since it is preferable to keep power and communications separate. The attachment to the power mast would require agreement by the power company.
- **Attach directly to the roof using a roof anchor bracket.** Although this is permitted under NESC Rule 234C, *“Communications conductors and cables may be attached directly to buildings or other installations”*, the configuration is not practical because customers will often object to how it looks, and the attachment points will be vulnerable anytime work is performed on or near the roof.

**Figure 3-11 Roof Anchor Method (Not Recommended)**

- **Erect a telecom service mast** that extends no more than 4 feet above the roof attachment point. To get the necessary mechanical strength and robustness, one needs to secure the mast to the building with appropriate hardware for the mounting surface (e.g., wall). It is advisable to have the home/building owner (customer) provide an attachment point, which could be a 2-inch diameter steel conduit, a 2 x 2 x 1/8-inch steel angle, or a 2- x 4-inch piece of wood. Having the customer supply the mast places the responsibility for mechanical strength and choice of steel or wood mast onto the customer. Taller masts can be used providing the attachment hardware is rated for the expected forces from the tensioned cable plus allowance for any wind and ice loadings.

**Figure 3-12 Communications Service Mast Options**

As a general guideline, the mast should extend down the side of the house/building for the same distance it protrudes above the roof edge. For example, for a mast that extends 4 feet above the roof, one would want at least an 8-foot long mast with the bottom 4 feet secured to the building every 12 inches. (See [Chapter 5](#) and GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*, for a discussion of attachment hardware.)

### 3.10.2 Vegetation Management

The aerial service drop to the house from the last pole often needs to pass through trees. The communications cables are designed to GR-3163-CORE, *Generic Requirements for Metallic Telecommunications Service and Distribution Drop Wires*, or similar industry specifications that include functional

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requirements for abrasion and impact resistance that can occur through contact with branches or animal activity (e.g., squirrels). Damage to a communications line is not an electrical or fire safety issue. During the initial installation of the service drop, the installer should avoid passing through trees and areas where anticipated tree growth will bring the drop wires in conflict with the vegetation. The maintenance of the service drop wire across the customer property is the responsibility of the property owner.

Vegetation management should be performed around supply and communications conductors as experience has shown to be necessary, but the focus of these vegetation management programs is on supply conductors to help prevent electrical faults between phase conductors and grounded conductors. Vegetation should be pruned or removed. This vegetation management is the responsibility of the power utility companies, following industry guidelines such as the Electric Reliability Standard FAC-003-2, *Transmission Vegetation Management*, which requires trees and other vegetation growing in or adjacent to the power line ROW be trimmed to prevent power outages caused by tree contact with a transmission line. The adjacent distribution communications lines will benefit from such tree trimming and management actions.

### 3.11 Current Trends Concerning Clearances and Separations

Poles are becoming more congested with space needed for the rapid expansion of communications broadband and wireless services and applications, along with a variety of Smart-Grid device deployments. Devices competing for pole space include:

- Smart-Grid devices to monitor and control supply circuits
- Wireless equipment – Antennas, power supplies and other devices/boxes
  - Densification will continue with many more antenna facilities serving microcells and DAS systems (smaller coverage areas) with 4G and 5G services with greater transmission speeds and video demands.
  - All these more numerous antennas will need fiber, wireless and microwave backhaul communications, as well as the power (equipment and cabling) to help run the facilities.
- Cameras to monitor and help control traffic, as well as for security surveillance
  - DOT traffic control and homeland security systems using multiple cameras and antenna units to maximize coverage and diversity
- Local speed indicators mounted low down on the pole (6 to 8 feet above ground level)
- Luminaries and street lights for public roadways as well as in

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- Private lighting/luminary systems used in parking lots and sports arenas
- Intelligent lighting systems with control exercised by a customer directly or through a utility.
- More and larger cabinets/boxes to serve broadband and optical fiber components associated with delivering services through Fiber-To-The-Node (FTTN), Fiber-To-The-Home (FTTH), and Broadband over Power Line (BPL) architectures:
  - Cabinets for VRAD, U-verse, Fios, xDSL, FTTx services
  - BPL interconnection boxes
  - Optical fiber cable storage loops
  - Backhaul communications nodes serving wireless/antenna facilities.
- Distributed power sources, including individual pole-mounted photovoltaic (PV)
  - solar panels feeding power into the grid - and backup power systems for remote equipment
- Power supplies for communications networks and circuits
- Overbuilding of competing communications service providers with wireline services, as well as an expansion of private networks with HFC and wireless (WiFi) network architectures.

The consequences of such crowding could include poles that may not be climbable and require an aerial lift or bucket device to access and maintain the communications plant. Any such reduction in access needs to be reflected in JUA language (see Chapter 26) and commensurate compensation in reduced attachment fees or accommodation to temporarily re-position or remove pole-mounted equipment to (1) allow repair and maintenance work on currently installed plant, and/or (2) enable new lines and equipment to replace, or be added to, the existing aerial plant.

### 3.12 Normative and Informative References Related to Clearances

1. IEEE C2, *National Electrical Safety Code (NESC)*, 2023 Edition.
2. NFPA 70, *National Electrical Code (NESC)*, 2023 Edition.
3. GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety – Generic Criteria for Network Telecommunications Equipment*.
4. GR-487-CORE, *Telcordia Generic Requirements for Electronic Equipment Cabinets*.
5. Bell System Practice (BSP) 621-200-205, *Poles - Markings and Insignia*.
6. AT&T Practice - 621-200-942 - *Marking Utility Poles with Visibility Strips*.
7. *Manual on Uniform Traffic Control Devices (MUTCD)* from Federal Highway Administration (2009 and 2012).
8. *California Pole Warning Signage MUTCD*.
9. *TVPPA Design and Construction Guidelines for Design and Transmission* (1992).
10. *Outside Plant - ABC Training* edited by Frank Lee.
11. *Highway/Utility Guide* - US DOT - Federal Highway Administration.
12. Federal Energy Regulatory Commission (FERC) Standard FAC-003-2 – *Transmission Vegetation Management*.
13. Avian Power Line Interaction Committee (APLIC), *Suggested practices for avian protection on power lines: the state of the art in 2006*. Edison Electric Institute.
14. Avian Power Line Interaction Committee (APLIC), *Reducing avian collisions with power lines: the state of the art in 2012*. Edison Electric Institute and APLIC. Washington D.C.
15. Whittington, D.M., and G.T. Allen - *Guidelines for raptor conservation in the western United States*. U.S. Fish and Wildlife Service, Region 9, Division of Migratory Bird Management, Washington, D.C. 2008.



## 4 Strand - Description and Stringing Tension

### 4.1 General

The primary function of suspension strand is to safely carry the load of the cable and cable apparatus and to provide this structural support during the nominal and expected weather conditions in the installation region.

**Note:** The terms “suspension strand”, “messenger strand” and “strand” are all used across the communications industry and apply to the multistranded galvanized steel wire rope that is placed between poles under appropriate sag and tension to which the communications cables are secured to the rope with lashing wire or hung off rings or hoops while closures and equipment are attached to the strand by brackets.

Galvanized steel suspension strand is generally available in two basic levels of galvanizing:

- **Type A** – General use under normal field conditions.
- **Type C** – Usually reserved for environments/applications where corrosion problems are known to exist, such as those found in coastal regions (see [Section 4.6.2](#)) subject to salty marine fogs and/or around industrial areas where significant pollution levels may exist.
- This chapter covers the types and sizes of strand recommended for use as suspension or guy strand. It also gives the maximum stringing tension for the different sizes of strand, including 4.7 M high-strength and 6.6 M extra-high-strength steel strand at various temperatures. The following general observations on the uses of the different strand sizes apply:
  - 2.2 M Strand – Generally used only for supporting drop cables between poles and buildings
  - 6 M and 6.6 M Strands:
    - 6.6 M strand is smaller, lighter, and less expensive than the 6 M strand.
    - Some companies permit these two sizes be used interchangeably for guying, but in general, the 6 M is preferred.
    - Span length limitations apply when using 6.6 M strand, with 6 M strand being preferred for longer spans.
  - 10 M Strand – The 10 M and 6 M strands are the more widely used sizes for guys and span strand applications for communications plant.
  - 16 M Strand – This strand size is mostly used to support large, heavy cables, i.e., cables with large pair counts, heavy armored construction or lead-sheath cable.
  - 25 M Strand – This large diameter strand is rarely used but is included in the [Chapter 4](#) tables along with data for other rarely used sizes (4.7 M and 11.2 M) for historical reference.

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It is critical for safe and reliable use of these strand products that the hardware used to attach the strand to anchors and pole are compatible and of the correct size with the strand. The strandvises, grips, and clamps all need to properly grip the galvanized surface of the strand to maximize bond strength without extensive damage that may decrease the effective breaking strength of the strand.

The licensee, as specified in the License Agreement, must furnish strand details as to breaking strength, tension at 60°F (15°C), and maximum tension under the applicable storm loading (light, medium, and heavy) as specified by the NESC.

## 4.2 Strand Description

Cables, in general, are supported on 6.6 M Extra High Strength (EHS) galvanized suspension strand, 6-M utility grade strand, or larger strand, as required by the load supported.

**Note:** Strand with Class A galvanizing designation A90 as per the American Society for Testing and Materials (ASTM) is recommended for use in areas where corrosive conditions are classified as normal. Strand products with Class C galvanizing (ASTM designation A363) should be used in areas classified as corrosive.

Strand used as guys will be of an adequate size to hold the load.

Table 4-1 shows the breaking strength of strand used for suspension strand and guys. Table 4-2 through Table 4-4 show the maximum stringing tensions allowed for suspension strands.

**Table 4-1 Strand Breaking Strength**

| Nominal Strand Size (Inch) [Notes 1, 2] | Minimum Breaking Strength (lb) [Note 3] | Normally Referenced as [Note 6] |
|-----------------------------------------|-----------------------------------------|---------------------------------|
| 3/16 [Note 4]                           | 2400                                    | 2.2 M                           |
| 1/4 HS [Note 7]                         | 4750                                    | 4.7 M                           |
| 1/4 EHS                                 | 6600                                    | 6.6 M                           |
| 5/16 [Note 5]                           | 6000                                    | 6 M                             |
| 5/16 [Note 7]                           | 11200                                   | 11.2 M                          |
| 3/8                                     | 11000                                   | 10 M                            |
| 7/16                                    | 16000                                   | 16 M                            |
| 1/2                                     | 25000                                   | 25 M                            |

**Notes:** [1] A 4.7 M HS is a 7-wire, high-strength strand. A 6.6 M EHS is a 7-wire, extra-high-strength strand. All other strands are “utility” grade.

- [2] Cables added (overlashed) to existing strand must meet load requirements of present in-place supporting strand.
- [3] Strand strength is based on ASTM standards, Telcordia MDP-326-175 (replaces PUB 55010) and CAO-7035.
- [4] Used only for supporting cable on pole-to-building attachments.
- [5] A 5/16-inch EHS may be used by some power companies for guying.
- [6] Strand sizes will generally be referred to as their "M" size.
- [7] 4.7 M and 11.2 M are included here for historical purposes only, as these strand sizes are not currently used.

The functional performance requirements for any steel strand wire used to support communications plant are covered in various documents such as:

- CAO-7035, *Galvanized Strand*, Issue 3, 1985 (also referred to as AT-7035)
- MDP-326-175, *Steel Wire Strand Specification* (replaces PUB55010).  
Materials and performance test criteria are taken from:
  - GR-2836-CORE, *Generic Requirements for Assuring Corrosion Resistance of Telecommunication Equipment in the Outside Plant*
  - ASTM A475, *Zinc-Coated Steel Wire Strand*
  - ASTM A855, *Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Wire Strand*
  - ASTM B117, *Corrosion Resistance Testing Using a Salt Fog Chamber*.

Any new or variations in traditional strand products for this application should be required to meet the specifications of these standards and meet the nominal strand sizes and minimum breaking strength defined in [Table 4-1](#).

Standard attachment hardware is normally sized for use with 6-M, 6.6-M, and 10-M strand products. If other strand sizes/products are used, it is important that the hardware used with such strand is tested for compatibility and functional performance prior to use.

### 4.3 Stringing Tension

It is imperative that the strand tension required to meet the application is calculated using an industry-approved strand tensioning tool to meet the minimum tensioning requirements for the strand size and cable weight for the existing pole line.

After the strand has been placed, it should be tensioned so that the final sag with cable in place conforms to clearances in [Chapter 3](#). See [Table 4-2](#) through [Table 4-4](#) for maximum stringing tensions.

**Table 4-2 Maximum String Tension – 4.7 M HS, 6.6 M EHS, and 6 M Steel Strand**

| Temperature |      | Stringing Tension in Pounds |                                |                     |
|-------------|------|-----------------------------|--------------------------------|---------------------|
| °F          | °C   | Spans Under 250 Feet        | Spans Between 250 and 450 Feet | Spans Over 450 Feet |
| 0°          | -18° | 900                         | 850                            | 775                 |
| 20°         | -7°  | 800                         | 750                            | 725                 |
| 40°         | 4°   | 700                         | 675                            | 650                 |
| 60°         | 15°  | 600                         | 600                            | 600                 |
| 80°         | 27°  | 500                         | 525                            | 550                 |
| 100°        | 38°  | 425                         | 475                            | 525                 |

**Table 4-3 Maximum Stringing Tension – 10 M Strand**

| Temperature |      | Stringing Tension in Pounds |                     |
|-------------|------|-----------------------------|---------------------|
| °F          | °C   | Spans Under 400 Feet        | Spans Over 400 Feet |
| 0°          | -18° | 2675                        | 2600                |
| 20°         | -7°  | 2475                        | 2450                |
| 40°         | 4°   | 2300                        | 2275                |
| 60°         | 15°  | 2100                        | 2100                |
| 80°         | 27°  | 1925                        | 1950                |
| 100°        | 38°  | 1725                        | 1800                |

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**Table 4-4 Maximum Stringing Tension – 16 M Strand**

| Temperature |      | Stringing Tension in Pounds |
|-------------|------|-----------------------------|
| °F          | °C   | All Span Lengths            |
| 0°          | -18° | 4425                        |
| 20°         | -7°  | 4150                        |
| 40°         | 4°   | 3875                        |
| 60°         | 15°  | 3600                        |
| 80°         | 27°  | 3325                        |
| 100°        | 38°  | 3075                        |

#### 4.4 Methods of Obtaining Stringing Tension

Determine the temperature of the air by placing a thermometer in a vertical position in approximately the same sun or shade conditions existing along the section of strand being tensioned.

Use a dynamometer to determine the tension of the suspension strand.

For best results, first pull the strand until it is tighter than the desired tension; then slack off until the desired tension is obtained. This extra tension should not exceed 125% of the designed stringing tension or 500 pounds, whichever is less.

The points at which strand tension should be measured under various conditions are as follows:

- Straight sections free from changes in grade:<sup>1</sup>
  - Less than 10 spans – Measure the tension near the middle of the section of strand.
  - 10 to 20 spans – Measure the tension first at a point about two-thirds of the distance from the pulling end; then, at a point about one-third of the distance from the pulling end.
  - Over 20 spans – Measure the tension first at a point about three-fourths of the distance from the pulling end; then, at a point about one-half of the distance; finally at one-fourth of the distance.

**Note:** The tolerance implied by phrases such as “...near the middle of...,” “...about two-thirds...,” and “...about three-fourths...,” in the above bullet items should be taken as nominally meaning within +/-10% of the span length.

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- Sections including changes in grade or corners:
  - Measure the tension first at the far side of the farthest corner or pole where change in grade occurs; then, at each corner or change-in-grade pole, working toward the pulling end.
  - As the desired tension is obtained in each portion of the strand being pulled, tighten the bolts of the suspension clamps.

## 4.5 Tensioning and Sagging of Cable Strand

When tensioning strand for the use of supporting cable(s), the strand shall be tensioned to:

- a. Provide sufficient support for the cable(s) and cable apparatus under the expected Outside Plant (OSP) weather conditions (i.e., heat, cold, ice, and wind)
- b. Meet clearance minimums stated in [Chapter 3, “Clearances.”](#)

The main purpose of the strand is to safely carry the load of the cable and cable apparatus and to structurally meet the OSP nominal weather and expected stormy conditions of a region.

It is imperative that this tension is calculated using an industry-approved strand tensioning tool to meet the minimum tensioning requirements for the strand size and cable weight for the existing pole line.

There are instances when tensioning strand to its recommended or full capacity could lead to contact with the existing cable plant. This is common when cables are placed between or below existing plant. In these cases, it is recommended to place the strand at a tension that will adequately support the cable meeting structural requirements and provide enough sag to comport with the existing aerial cables.

If a conflict occurs between the strand tension requirements and matching the sag of adjacent plant, rearrangement of existing plant may be required such as moving plant up or down on the pole.

At all times, cable clearances must be maintained over roadways and from the power facilities, as detailed in [Chapter 3, “Clearances.”](#)

**Slack Span Construction** - The strands discussed in this Chapter 4 are also used for slack spans. If existing joint-use poles are too congested for planned wireless attachments, some users are erecting wireless-only unguyed poles where antennas and associated equipment mounted on the pole are served powering and backhaul communications cables across slack span strand to the main pole line.

Slack span construction and allowable tensions are discussed in Sections 9.6 and 9.7. Wireless-only poles follow the same requirements for wooden poles (Chapter 12-13 and ANSI O5) are further discussed in Chapter 15.

## 4.6 Strand Choices

The size of suspension strand used in an aerial OSP setting is dictated primarily by three factors:

1. The diameter and weight (lbs/ft) of cable,
2. Span length (see Note below), and
3. Loading area rating that includes the expected wind and ice loadings.

**Note:** The average pole span length (between poles) is approximately 100 to 125 feet in most areas other than rural districts where span lengths can be much greater. Rural areas are mostly in outer districts where there is limited number of residential homes. Often this type of area is found in farming regions.

The exact type and grade of strand selected can also include consideration of:

4. Corrosion potential of the surroundings such as may be found in marine coastal zones and areas where industrial pollution may be significant (Class C grades are used for these susceptible areas).
5. Local code requirements which can vary.

**Note:** In addition to the NESC rules that provide minimum requirements for much of the USA, these local variations can include requirements in the California GO 95 rules and design rules from individual utilities that may include additional safety factors for higher reliability.

### 4.6.1 Suspension Strand Choices for Optical Fiber

Optical fiber was first deployed in the early 1980s when most of it was placed below ground for two primary reasons:

1. The fiber was predominately for backbone networks between major points in the network where underground manhole systems were available, and
2. These underground facilities were thought to provide increased protection and security.

As the optical fiber plant became more common and widespread, not just for feeder routes, but also for residential and Fiber-To-The-Antenna (FTTA) applications, companies began to place overhead fiber on poles. The fiber plant, regardless of it being backbone or residential, requires extra consideration from service providers because of concerns about the greater bandwidth, more sensitive information, higher performing services, and a high density of circuits that travel through the fiber. Because of the high reliability demanded for these services, the traditional practices of the communications industry increased the requirement for suspension strand for the optical fiber cable.

As a result, several network providers elected to use the larger, stronger 10M strand for fiber cables as providing extra protection and safety factors for the expensive and critical optical fiber cables (i.e., providing higher reliability of aerial plant). The 10 M strand is rated at 11,000 lbs breaking strength compared to 6,000 lb of the 6 M strand. This higher strength capacity can prove important under storm conditions when ice accumulates on cable(s) and high winds are involved impacting the overall load on the strand. Although the small diameters of fiber cables that range from approximately ~1 inch (864 fiber cable) to 0.5 inch (72 fiber cable) would suggest that any ice build-up would be thin and relatively light, the larger bundles created by having several cables over-lashed to one strand provide a much greater surface area for ice accumulations. The larger cable bundles require greater strand strength to avoid low cable sags over roadways. Falling tree limbs or trees can also prove to be a problem during hurricanes, winter snow and ice storms, or from trees that are not healthy. The 10 M strand would provide increased strength and possibly greater protection. However, leaning/falling trees and/or falling branches can damage the cable regardless of the strand size.

#### 4.6.2 Coastal Zones

Strand located near to coastal regions and water sources need enhanced corrosion resistance not only because of (a) the direct exposure of the metal surface to salt fog, marine and industrial atmospheres, and (b) the tension under which the strand is placed. Related factors that need to be considered to determine susceptible areas that require Class C galvanized materials include:

- Climate, wind and storm maps to determine areas where enhanced transport of salt air inland is likely to occur.
- Temperature factors – Higher temperatures will place more humidity and salt into the air, and fogs may develop more easily in areas prone to weather fronts meeting over cool or warm earth.
- Loading zones – For example, Class B construction may require larger strand sizes compared to Class C construction.

For painted steel or coated metallic boxes (as per GR-487), a coastal zone was defined as between 2 and 5 miles.

Since the metallic strand is directly exposed and under constant tension, the sensitive zone near coastal environments where additional corrosion resistance is warranted should be longer at between 10 and 25 miles, depending on the local wind and weather patterns noted above.

The larger value of 25 miles would apply to areas where specific circumstances such as strong winds, flat ground and significant temperature swings could extend the influence and reach of humid marine (salty) air. Examples of such zones would be the areas such as along the eastern seaboard, the Gulf Coast and northwest Cascade regions, e.g., Florida, North/South Carolina, Louisiana,



San Francisco Bay and Puget Sound.

#### 4.6.3 Strand Size Considerations - 6 M Versus 6.6 M

The use of 6.6 M strand was expanded in the 1990s to accommodate lightweight cable products such as optical fiber cables and CATV coaxial cables, as well as for use as the metallic support strand used in self-support cable applications.

Some users elected to use the larger, stronger 10 M for fiber cables as providing extra protection and safety factors for the expensive and critical optical fiber cables (i.e., providing higher reliability of aerial plant). Some communications providers have reserved the 6.6 M strand for use with self-support cable where only a single well-defined cable is being supported.

Other users have suggested using 6.6 M only and eliminating 6 M based on the facts that the 6.6 M strand is smaller, lighter, and less expensive than 6 M strand. However, this strategy does introduce some design concerns:

1. **Span limitations** shall apply, particularly with medium-to-heavy weight cables, or where multiple cables are lashed together.
2. Issues around **support and placement hardware** need to be considered – different sized hardware and clamps are needed to help ensure that secure splices and strong attachments are achieved.
3. **Long-term reliability** of the smaller diameter strand needs to be factored into operational and engineering decisions.

The 6 M and 6.6 M strands are interchangeable as a general concept; e.g., each strand providing adequate support for the cables over the average span lengths of 100-125 feet in light loading zones. The 6 M is often preferred because of its capability to support longer spans for the medium-to-heavy cables (or where several cables are lashed together).

**Span Limitations** – If all the cables are light (e.g., 0.5 lb/ft), then long spans can be deployed using the 6.6 M strand. For medium-to-heavy weight cables, or where several cables are to be lashed together, span limits exist for the 6.6 M strand since it may stretch too much and sag under tension (see [Table 4-5](#) or [BSP-627-200-015](#) for details). The combination of required stringing tensions and sags for the two strand sizes are different, and one needs to use the appropriate ones for cable, strand and span application (see [BR-627-210-018](#)). As long as one stays within the appropriate specified limits, each strand size should perform adequately.

The design engineers and technicians must strictly adhere to the sags, tensions, pull- on-pole and other construction guidelines to help ensure that a change from 6 M to 6.6 M strand does not compromise proper ground clearances.

**Support and Placement Hardware** – There are a variety of support and attachment hardware issues, as well as tool-related concerns, which need to be considered when changing between strand sizes. [Table 4-5](#) compares some of the key properties and applications features for the two strand sizes.

- **Reducers** – The concern with reducer hardware for 6.6 M strand occurs when the strand sizes change along the pole run. The hardware for reducing 10 M to

6.6 M is not available or permitted for safety and reliability concerns. Effective alternative practices can be used with (a) dead-ending the strands, (b) applying a false dead-end, and (c) guys to offset load differentials due to different tensioning requirements of the strands. The required objective is to properly distribute loads/tensions between the larger strand (10 M), guy, and smaller strand (6.6 M) while minimizing pull forces on the pole.

- **Sizes** – Appropriately sized attachment and support hardware such as strandvises, reducers, grounding/bonding connectors, and suspension clamps are available for each strand size. Of course, it is critical that matching type and size hardware is used to properly support the 6.6 M strand. If 6.6 M strand is to be exclusively used, then the design/planning engineer needs to be aware and clearly specify 6.6 M strand in plans with appropriate span lengths, sags, tensions and hardware.
- **Lashing Machines** – The construction work force must verify that their standard cable lasher will operate properly on 6.6 M strand. The wheel mechanism of the lasher that grabs and smoothly runs along on the strand must have a snug fit to the strand for the lasher to work properly. The wheels often have an adjustable coupler that needs to be able to be adjusted down for the small diameter (1/4-inch) 6.6 M strand. In the past, some adjustable fittings have proven unreliable and have slipped during operation on the 6 M strand. One will need fully adjustable lashers or separate lashers for different strand sizes.
- **Suspension clamps, hangers and hardware** – Construction work force also needs to ensure that straight hangers (strand clamps) in use today for 6 M, 10 M and 16 M qualify for use with the smaller diameter 6.6 M strand. There is a direct correlation between guys and anchor size requirements to the suspension strand size. By increasing the suspension strand from 6 M to 10 M, anchor and guy sizes are required to be increased to meet 10 M strand requirements.

**Table 4-5 Strand Size Comparison - 6 M Versus 6.6 M**

| Property                                   | Strand Size Designation<br>6 M (Utility Grade)                                                                                                                                                            | 6.6 M (EHS)   |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Size                                       | 5/16 inch                                                                                                                                                                                                 | 1/4 inch      |
| Nominal Wire Diameter (7 wires per strand) | 0.109 inch                                                                                                                                                                                                | 0.080 inch    |
| Breaking Strength (lbs)                    | 6,000                                                                                                                                                                                                     | 6,650         |
| Minimum Elongation                         | 10%                                                                                                                                                                                                       | 4%            |
| Cost (\$)                                  | 2 X                                                                                                                                                                                                       | X             |
| Handling Ease                              | 6.6 M is smaller diameter and, therefore, easier to bend and handle than 6M                                                                                                                               |               |
| Reducer configurations practices           | 6 M to 10 M and 6 M to 6.6 M                                                                                                                                                                              | 6 M to 6.6 M  |
|                                            | 6.6 M to 10 M reducer not permitted for safety concerns                                                                                                                                                   |               |
|                                            | To go from 10 M to 6.6 M, one needs to (a) dead-end the strands, (b) apply false dead-end, and (c) add guys/braces to properly distribute the loads and tension from strands properly along the pole line |               |
| Maximum Span Length Allowed (*) in feet    |                                                                                                                                                                                                           |               |
| Heavy Loading Area                         |                                                                                                                                                                                                           |               |
| 0.5 lb/ft cable                            | 290                                                                                                                                                                                                       | 440           |
| 1 lb/ft cable                              | 220                                                                                                                                                                                                       | 230           |
| 2 lb/ft cable                              | 150                                                                                                                                                                                                       | 115           |
| 3 lb/ft cable                              | 115                                                                                                                                                                                                       | Not permitted |
| Medium Loading Area                        |                                                                                                                                                                                                           |               |
| 0.5 lb/ft cable                            | 485                                                                                                                                                                                                       | 440           |
| 1 lb/ft cable                              | 350                                                                                                                                                                                                       | 230           |
| 2 lb/ft cable                              | 200                                                                                                                                                                                                       | 115           |
| 3 lb/ft cable                              | 140                                                                                                                                                                                                       | Not permitted |
| Light Loading Area                         |                                                                                                                                                                                                           |               |
| 0.5 lb/ft cable                            | 485                                                                                                                                                                                                       | 440           |
| 1 lb/ft cable                              | 370                                                                                                                                                                                                       | 230           |
| 2 lb/ft cable                              | 215                                                                                                                                                                                                       | 115           |
| 3 lb/ft cable                              | 140                                                                                                                                                                                                       | Not permitted |

(\*) Maximum span lengths for typical ALPETH or STALPETH cables from BSP 627-200-015 and BR-627-210-018.

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**Long-Term Reliability** – Finally, one needs to assume that whichever strand is used, the product has been evaluated against adequate specifications noted above in [Section 4.2](#). The smaller diameter 6.6 M strand with smaller diameter wire components will be more susceptible to corrosion and fracture. Therefore, a comprehensive product assessment is particularly necessary to help ensure the corrosion protection (galvanizing), good quality steel, and consistent, reliable manufacturing processes are being used in the construction of the 6.6 M strand.

## 4.7 Overlashed Cables and Strand-Mounted Equipment Considerations

If a communications company needs to upgrade or supplement its network by means of adding a new cable (powering circuits, new optical fiber cables, more distribution cables or communications backhaul for wireless equipment), there are basically two options:

1. Adding a new messenger to support the new communications cable, or
2. To lash (“overlash”) the new cable to an existing messenger strand, usually owned by the same company.

In addition to operational efficiency, the major advantages to the latter procedure include space savings and reduced loads on the pole. It is therefore not surprising that this practice has been widely adopted, consistent with the recommendation in Section 27.1 for optical fiber cables which states:

*“Where applicable, consider using overlash construction methods rather than placing new strand.”*

Because of the benefits of this practice in expanding the availability of broadband service access in the United States, the FCC has ruled (47 CFR § 1.1415 Overlashing) that a utility shall not require prior approval for:

- (1) An existing attacher that overlashes its existing wires on a pole; or
- (2) For third party overlashing of an existing attachment that is conducted with the permission of an existing attacher.

The FCC does, however, allow an exception if – at its own cost – the utility “determines that an overlash would create a capacity, safety, reliability, or engineering issue”, for which it must provide specific documentation. Thus, in general, the FCC ruling places the primary responsibility for ensuring the safety and performance of the pole and related facilities on the party performing the overlash: *“A party that engages in overlashing is responsible for its own equipment and shall ensure that it complies with reasonable safety, reliability, and engineering practices.”*

Although the overlashing process is a relatively minor, unobtrusive process, with usually small implications regarding pole loading and strength issues, the quantitative effects can be over-estimated (exaggerated) because of inappropriate, oversimplified assumptions for determining the bundle size of

the new strand + cable configuration. Therefore, whereas it may appear convenient to provide only the diameter and weight for any added cables as part of the application/approval process, it is important to indicate, and/or use, the expected size of the resulting bundle for the purpose of load calculations. This value may be considerably less than that corresponding to simple additive sum of the various diameters, which could result in assumed wind forces possibly double the more realistic and accurate values. The approximate bundle diameter may be determined manually (e.g., graphically or empirically), but is readily provided by the available software tools (see Chapter 13, and Section 13.10 in particular, for a more detailed discussion on overlap calculations).

**Note:** One example of available industry software tools is the SpanMaster® application by provided as a courtesy to the industry by Commscope®.

Similarly, it would be advisable to provide an estimate of the resulting (peak) storm tension for the messenger strand, for the relevant storm zone/district, rather than only confirming the tension remains within the allowable 60% limit. The use of the 60% default value may be excessively conservative and lead to unnecessarily strict design criteria for the guys and anchors at dead-ends and poles at line angles. The tension for the strand at ambient conditions may be obtained by use of the following formula:

**Tension (lbs)**

$$= \text{total wire weight (lbs/ft)} \times [\text{span length (ft)}]^2 / [8 \times \text{midspan sag (ft)}]$$

Observation of the sag at ambient conditions (e.g., 60°F), in combination with the known weights of the supported wires/cables (including messenger), may then be used to calculate the corresponding tension. If the sag is measured prior to the addition of the new cable(s), the determination of the subsequent tension (and sag) at either ambient or storm conditions may also be obtained by using the same software tools. If necessary, adjustments may be made to accommodate clearances, which may affect the corresponding storm tension.

When additional equipment, including for wireless applications, is strand mounted on a messenger strand, in the vicinity of the pole, the effects may be conveniently considered as equivalent to an additional overlap, using the corresponding guidelines for overlapping events. It is recognized that the guidelines do not address the possibility that the additional overlapped cable(s) may result in excessive sag and inadequate clearances to surfaces below (under ice loading and/or high temperature conditions) or reduce “nominal/installation” clearances to communications facilities below to less than desired levels.

Using a uniform distributed load to simulate the effect of adding a strand-mounted equipment closure to the messenger is reasonable guide in many cases. However if the mounted equipment is heavy and/or located close to the pole, then the additional sag across the span can be asymmetric resulting in

large added sags at the point of mounting that may cause conflicts with adjacent strands. The point loading can possibly result in reduced sag elsewhere along the sag bringing the line closer to a higher strand.

**Note:** More detailed discussions of such point load issues can be found in Section 8.6 and Appendix E of “*Overhead Distribution Lines – Design and Applications*” by Lawrence M. Slavin that is an excellent resource for information on strength, loading, sag and tension questions along with example calculations.

Thus, if it becomes necessary to re-tension the messenger to reduce such sag(s), in addition to verifying that peak (storm) tensions remain within the 60% limit, it may be advisable to perform a loading analysis to verify the pole system has sufficient capacity to withstand the increased tension(s), particularly at line angles or dead-ends.

When adding a new attachment to a pole line, it is always an option to perform a full pole loading analysis (PLA), and such a full analysis is sometimes required and/or desired for documentation purposes. It may also be desirable to perform a PLA for complicated configurations which may be otherwise difficult to analyze. However, such a formal study is often not necessary, especially if the purpose is to determine if particular poles would remain compliant with the NESC with the added lines or facilities.

Some of the possible alternatives to a formal PLA are reviewed in Chapter 13 (see Section 13.10).

## 4.8 Normative and Informative References Related to Clearances

1. CAO-7035, *Galvanized Strand*, Issue 3, 1985 (also referred to as AT-7035).
2. MDP-326-175, *Steel Wire Strand Specification* (replaces PUB 55010).
3. GR-2836-CORE, *Generic Requirements for Assuring Corrosion Resistance of Telecommunication Equipment in the Outside Plant*.
4. ASTM A475, *Zinc-Coated Steel Wire Strand*.
5. ASTM A855, *Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Wire Strand*.
6. ASTM B117, *Corrosion Resistance Testing Using a Salt Fog Chamber*.
7. NFPA 70, *National Electrical Code (NESC)*, 2017 Edition.
8. BSP-627-200-015: *Suspension Strand Selection – Copper Conductor Cables in All Loading Areas*.
9. BR-627-210-018: *Suspension Strand – Tension and Sags: Copper Conductor Cables*.

“*Overhead Distribution Lines – Design and Applications*” by Lawrence M. Slavin – IEEE Press – Wiley 2021.

# 5 Pole Line Hardware - Description and Use

## 5.1 General

This chapter covers the description and use of various types of hardware that are recommended for attaching suspension strand to line poles, corner poles, and dead-end poles and also for terminating guy strand. Illustrated in this chapter are those situations most generally encountered. Check with the local communications company if additional information is required for other situations.

In addition to the figures in this chapter, tables are included to provide a ready reference on the types of hardware recommended for attaching suspension strand and guy strand in various situations.

In some cases, different types of hardware are shown performing the same function. All types shown are acceptable, with the selection being at the discretion of the company placing the facilities.

At corner poles, where larger cables are carried on the strand, the communications company recommends that either a spacer (extra nuts) or a pole strand connector be installed between the suspension clamp and the pole to serve as a spacer to keep the cable from rubbing against the pole. Although providing this spacer is a good construction practice, communications companies may not insist that other companies using the pole adhere to this practice.

Hardware may be referred to in terminology commonly used by manufacturers or the communications company. For example, a “machine bolt,” used to support a cable-suspension clamp, is called a “suspension bolt” in communications company terminology, and “eye bolts,” straight or angled, are called “A” and “B” bolts, respectively.

The prime focus of this chapter is on hardware for wooden poles. However, [Section 5.15](#) provides guidance on attachment and support hardware for non-wood utility poles, which are becoming more widely used in the power and telecommunications industry.

### 5.1.1 Hardware Functional Requirements

The primary purpose of pole attachment hardware is to secure the cable and associated aerial plant facilities to poles and to help facilitate necessary plant rearrangements. An aerial plant network requires high-quality reliable hardware to:

- Structurally support the distribution cable plant
- Provide directional guying to accommodate lateral stresses created on the pole by pole line configurations and pole loading configuration

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- Provide the physical support and protection for:
  - Drop cable plant from the pole to the customer premises
  - Transition cable plant from the aerial network to underground and buried plant
  - Small and large GR-487-type cabinets, as well as other boxes and closures that are directly attached to the pole.
- Provide the means for safe and effective grounding, bonding, and isolation connections for the metallic and dielectric components of the network.

The Ericsson - NIS document GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*, issued in 2012, provides functional requirement criteria common to pole line hardware for use on utility poles made of wood, steel, concrete, or Fiber-Reinforced Composite (FRC) materials. GR-3174 includes the following information to help ensure that hardware is of high quality and has the reliability to perform well under the expected application and environmental stresses for more than 35 years:

- Form, fit and design criteria for generic hardware, as well as specific design features of selected wooden pole hardware
- Specific material guidance on bulk metals, as well as protective (corrosion- resistant) surface coatings
- Mechanical strength requirements and cyclic fatigue tests.

**Note:** All the hardware must be galvanized to ASTM A153 Grade C or an equivalent protection level against the expected corrosion environment (see GR-3174).

The need for using high-quality raw materials, good designs and excellent manufacturing processes is critical since the failure of pole line hardware can have significant damaging consequences for the public, workers and facilities. The testing of products to specifications such as GR-3174, coupled with product selection for the application and environment, will reduce instances of broken bail wires, excessive corrosion, loose connections of grips and jaws with strands and poles, and other failure modes.

### 5.1.2 Hardware Categories

Within the applications for pole hardware, there are five distinct categories that require different product properties.

**Category 1:** Structural Support of Pole: Where the hardware is required to maintain high mechanical strength and robustness under large tensile, torsional, and environmental stresses. Specific hardware examples include the following items:

- Guy Wires and Anchor Bolts



- Crossarm Attachments.

**Category 2: Physical Support of Distribution Cables and Plant:** Where the components need to have medium-to-high strength and durability, particularly under cyclic mechanical strains (tensile, torsional, and compression) and environmental stresses (sunlight, rain, diurnal temperature swings, and wind). This hardware will hold strand and cables in place, as well as be the support point for cabinets (small and large). Specific hardware examples include the following items:

- Strand Connections
- Pole-Cable Attachment Hardware
- Bolts, Compression, Parallel Groove Bolts, Connections, and Clamps.

**Category 3: Support and Protection of Drop Plant:** Where the hardware is required to have medium strength and high durability under tensile loads; frequent cycles of load and relaxation strains; and long-term exposure to environmental stresses such as sunlight, diurnal temperature swings, rain, wind and electrolytic/ galvanic corrosion forces. The most commonly used items in this category are drop clamps and associated pieces such as wedge clamps, drive hooks, and drive rings.

**Category 4: Grounding, Bonding, and Guiding Hardware:** Where these components need medium strength to provide effective electrical conductance or dielectric isolation under environmental stresses of high/low temperature extremes, wind pressure, and driving rain. In particular, the hardware needs to be resistant to electrolytic/galvanic corrosion forces such as salt fog, acid rain, pollutant gases, stray currents, and induced currents. The electrical connection or dielectric isolation provided by these pieces needs to be maintained under cyclic vibrations.

- Grounding and Bonding Hardware
- Pole Steps (Pre-drilled versus post-installed steps)
- U-Guards and Conduit.

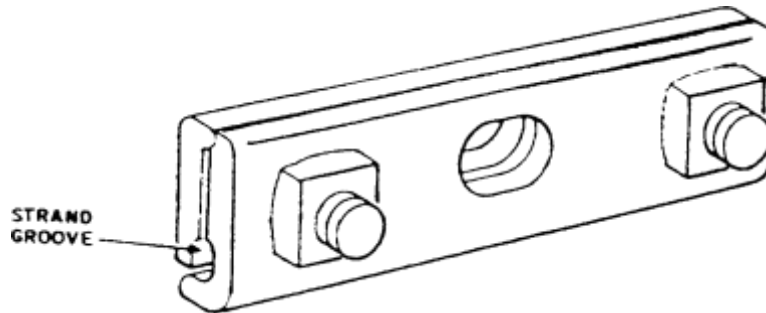
**Category 5: Fasteners:** These include bolts, nuts, screws, lags, nails, and staples, as well as general fastener hardware, which need to be resistant to outside weather conditions (e.g., sunlight, water, rain, storm). These fasteners need to retain their adhesive or gripping strength to the pole during exposure to the salt fog, acid rain, and polluting conditions.

## 5.2 Suspension Clamps

A cable-suspension clamp, as shown in [Figure 5-1](#), supports all sizes of suspension strand at in-line poles and 6.6 M or 6 M strand at corner poles with less than a 10-foot pull. The suspension clamp must be a type recommended for the size of the suspension strand used. The appropriate

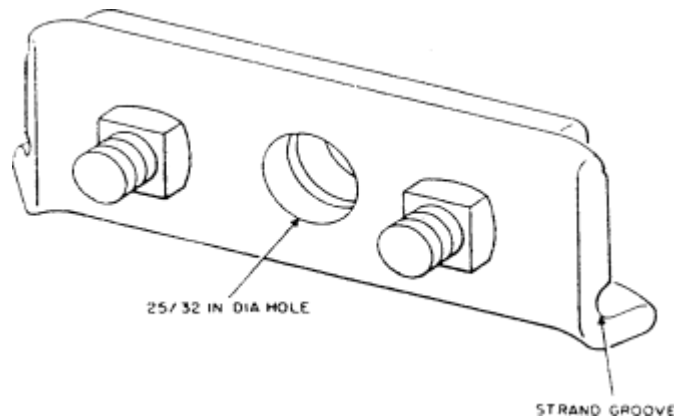
suspension clamp must be used with self-supporting cable. It must be placed so the strand groove is below the suspension bolt.

**Figure 5-1 Cable-Suspension Clamp**



The corner-suspension clamp (Figure 5-2) supports 6.6 M or 6 M suspension strand at corners where the pull is 10 to 50 feet. At any corner where the pull is greater than 50 feet, the strand must be dead-ended and guyed each way.

**Figure 5-2 Corner-Suspension Clamp**

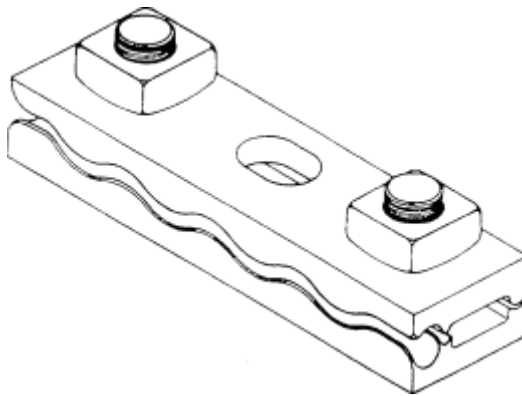


A corner clamp must be used at railroad crossings where the pull exceeds 5 feet (1.5 m).

Figure 5-3 shows a C cable clamp. This galvanized malleable iron clamp is installed over the jacketed strand. It is a 3-bolt clamp and has serpentine grooves to prevent slippage of the jacketed strand through the clamp. The nuts on the clamp are the same size as the nuts on the 6 M cable-suspension bolt. The C cable clamp may be used on in-line poles and at corners with a pull of 25 feet or less. This clamp is installed without slitting the web of the cable.

**Note:** Since electrical contact with the strand is not provided, if grounded guys are required, a separate bond between the guy and the strand will be necessary.

**Figure 5-3 C Cable Clamp**



### 5.3 Suspension Bolts

Suspension bolts are used to secure the suspension clamps to the pole. The bolts are available with one end threaded or with both ends threaded (Figure 5-4). The double threaded type bolt is generally used where it is planned to place two strands, one on each side of the pole, at the same level.

**Note:** Double-threaded type (B-bolt) may not be used for dead-ending or guying.

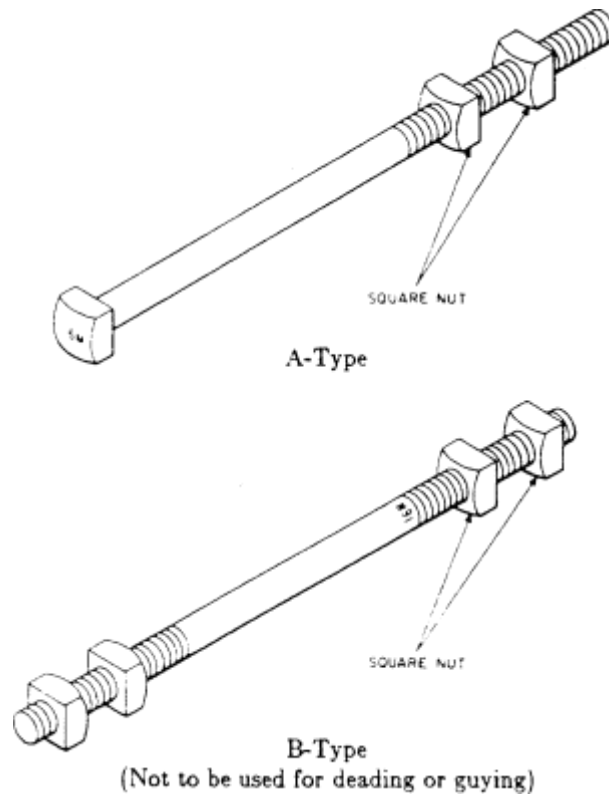
**Figure 5-4 Suspension Bolts for Supporting Suspension Clamps**

Table 5-1 lists minimum breaking strengths for suspension bolts.

**Table 5-1 Minimum Breaking Strengths**

| Bolt Size Diameter<br>in Inches | Minimum Breaking Strength<br>in Pounds [Note 1] |
|---------------------------------|-------------------------------------------------|
| 5/8                             | 12,400                                          |
| 3/4                             | 18,300                                          |
| 1                               | 33,200                                          |

**Note [1]** The minimum breaking strength is based on ANSI Standards. Also refer to GR-3174 for guidance on the minimum strength of pole hardware.

Table 5-2 lists the characteristics of cable-suspension bolts.

**Table 5-2 Characteristics of Cable-Suspension Bolts**

| Bolt Type | Bolt Sizes (Inches) |                                   | Maximum Size of Guy for Which Marked Bolt May Be Used | Marking |
|-----------|---------------------|-----------------------------------|-------------------------------------------------------|---------|
|           | Diameter            | Length                            |                                                       |         |
| A         | 5/8                 | 8, 10, 12, 14, 16, 18, 20, 22, 24 | 10M                                                   | 10M     |
| A         | 3/4                 | 10, 12, 14, 16, 18                | 16M                                                   | 16M     |
| A         | 1                   | 12, 14, 16, 18, 20, 22            | 25M                                                   | 25M     |
| B         | 5/8                 | 10, 12, 14, 16, 18, 20, 22        | 10M                                                   | 10M     |
| B         | 3/4                 | 10, 12, 14, 16, 18, 20            | 16M                                                   | 16M     |

Suspension bolts may be used as follows:

- With a guy hook for attaching a guy to a pole (Figure 5-4, “A” bolt)
- With a guy hook for attaching a guy and a suspension clamp on opposite sides of a pole (Figure 5-4, “A” bolt)
- With two guy hooks for attaching a guy and a strand dead-end on opposite sides of a pole (use “A” bolt only).

The holes bored through the pole for suspension bolts should be 1/16-inch larger than the diameter of the bolt.

The length of the bolt to be used is determined by the diameter of the pole plus the amount required to extend the bolt through the suspension clamp and nuts. The bolt must be long enough to extend at least two complete threads beyond the outer nut.

**Note:** The end of the bolt must not extend more than 1-1/2-inches beyond the nut. Any excess must be cut off.

## 5.4 Suspension Screws

The cable-suspension screw (Figure 5-5) attaches a cable-suspension clamp to a jointly used pole where the use of a cable-suspension bolt would result in improper clearance from an electrical supply vertical run or bracket and where it is impractical to have the supply attachment moved to provide clearance for the bolt. An installed cable-suspension screw is shown in Figure 5-6.

**Figure 5-5 Cable-Suspension Screw**

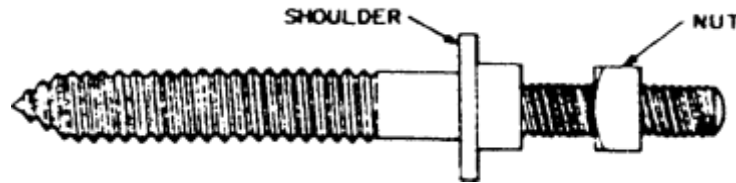
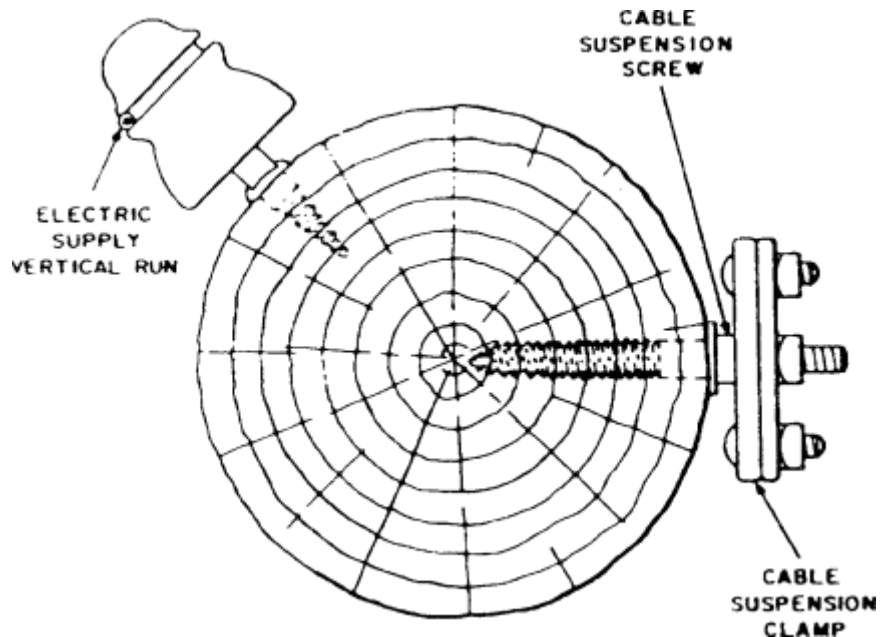


**Figure 5-6 Installed Cable-Suspension Screw**



Do not use a cable-suspension screw under the following conditions:

- At railroad crossings

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- In bolt holes larger than 11/16-inch in diameter
- If the pole shows evidence of decay or checking to the extent that there would be a tendency for the screw to loosen.

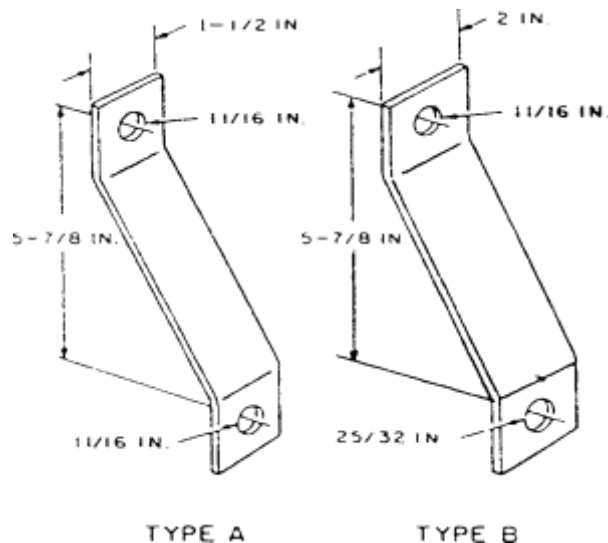
Install the cable-suspension screw as follows:

1. Bore a lead hole on the pole 5 inches deep using an 11/16-inch bit.
2. Turn the cable-suspension screw into the lead hole, using a suitable wrench, until the entire shoulder surface of the screw bears firmly against the pole. ***Do not drive the screw into the pole.*** Driving weakens the wood fibers and impairs the holding power of the screw.

## 5.5 Reinforcing and Support Straps

The two sizes of reinforcing straps are shown in [Figure 5-7](#). For the purposes of this section, the straps are coded A and B. *Type A* has an 11/16-inch diameter bottom hole and is used over a 5/8-inch bolt or suspension screw. *Type B* has a 25/32-inch diameter bottom hole and is used over a 3/4-inch bolt.

**Figure 5-7 Reinforcing Strap**



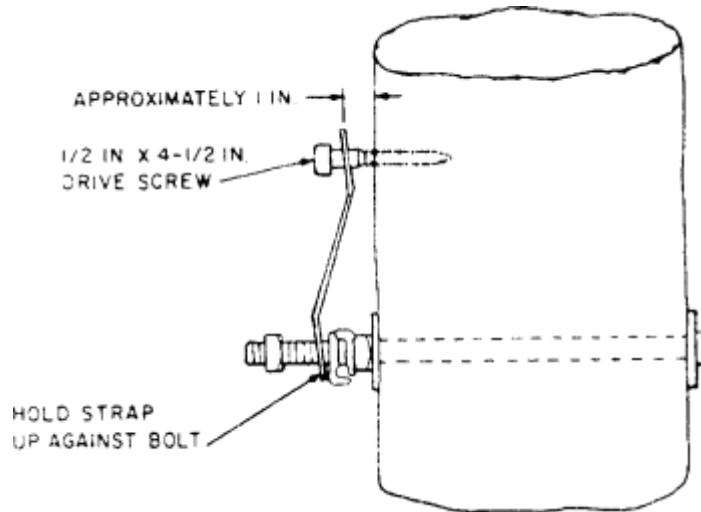
Reinforcing straps prevent the bending of the suspension bolts or suspension screw that supports the cable-suspension clamp. Straps are used for the following conditions:

- When the suspension clamp is spaced from the pole by two nuts and a washer or by a pole strand connector
- When there is a downward change in grade of 10% or more

- When the cable is supported on a 6 M suspension strand in accordance with [Table 5-3](#) in [Section 5.7](#).

A 1/2-inch by 4-1/2-inch drive screw can be used to attach the top of the reinforcing strap, as shown in [Figure 5-8](#), except where a 5/8-inch suspension bolt is required.

**Figure 5-8 Installing Reinforcing Strap Using Drive Screw**



A 5/8-inch suspension bolt is required to attach the top of a reinforcing strap when the following conditions exist:

- When two reinforcing straps are used to support the bolt
- When a pole strand connector is used as a suspension clamp spacer
- When the cable-suspension bolt is less than 22 inches from the top of the pole
- At railroad crossings
- When two suspension strands on opposite sides of the pole are attached to a single suspension bolt and both require reinforcing straps.

When using a bolt to attach the top end of a strap, install the reinforcing strap as follows:

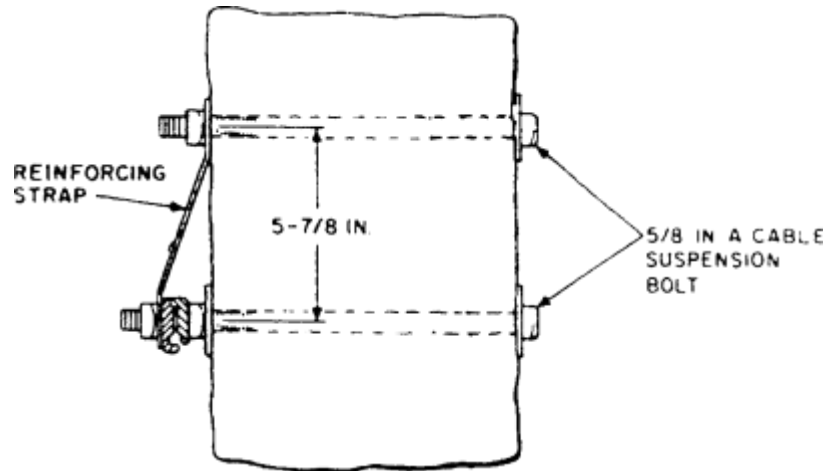
1. Bore an 11/16-inch hole for the strap bolt 5-7/8 inches above and parallel to the suspension bolt hole. Bore from the strand side of the pole.
2. Place the strap on the suspension bolt and run the nut up sufficiently to keep the clamp and strap from falling off. ***Do not tighten yet***



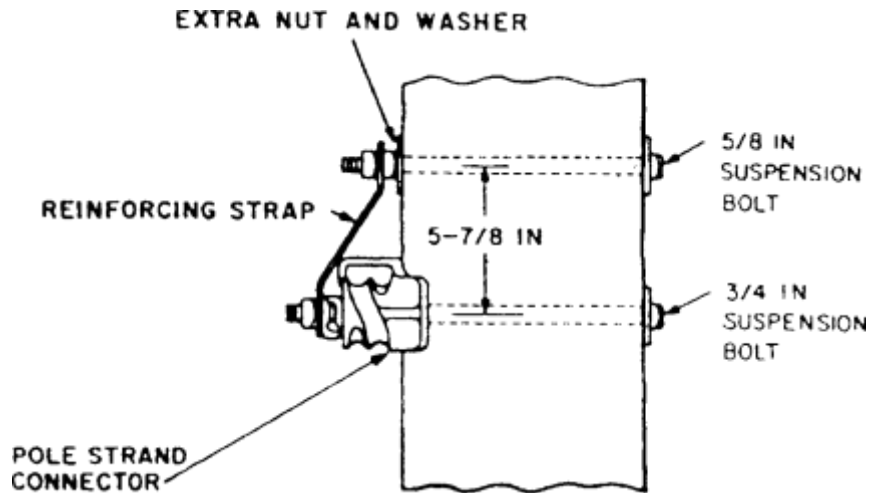
3. Place a 5/8-inch bolt in the top hole and through the strap.
4. Tighten the strap to the pole.
5. Next, tighten the nut on the suspension bolt.

A completed installation is shown in [Figure 5-9](#).

**Figure 5-9 Installing Reinforcing Strap Using Bolt**

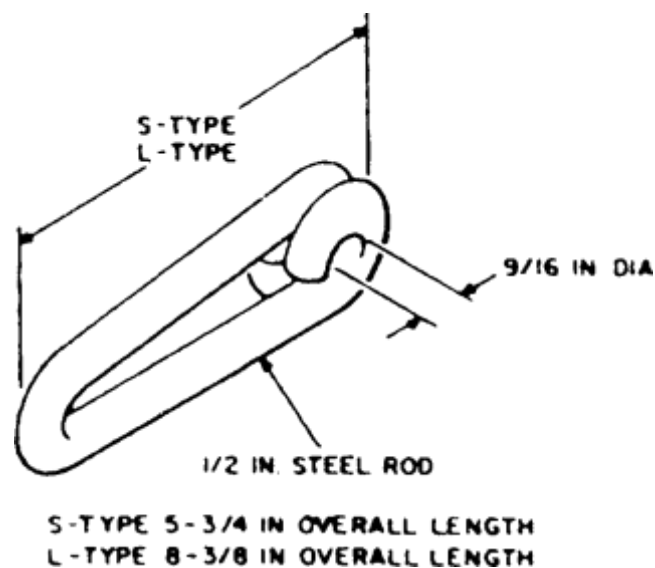


When a pole strand connector is used to space the clamp, use a nut and washer to space the reinforcing strap and straps from the pole, as shown in [Figure 5-10](#).

**Figure 5-10 Nut and Washer Used to Space Reinforcing Strap**

## 5.6 Reinforcing Links

Two sizes of reinforcing links are shown in [Figure 5-11](#). For the purposes of this section, the links are coded as S and L.

**Figure 5-11 Reinforcing Link**

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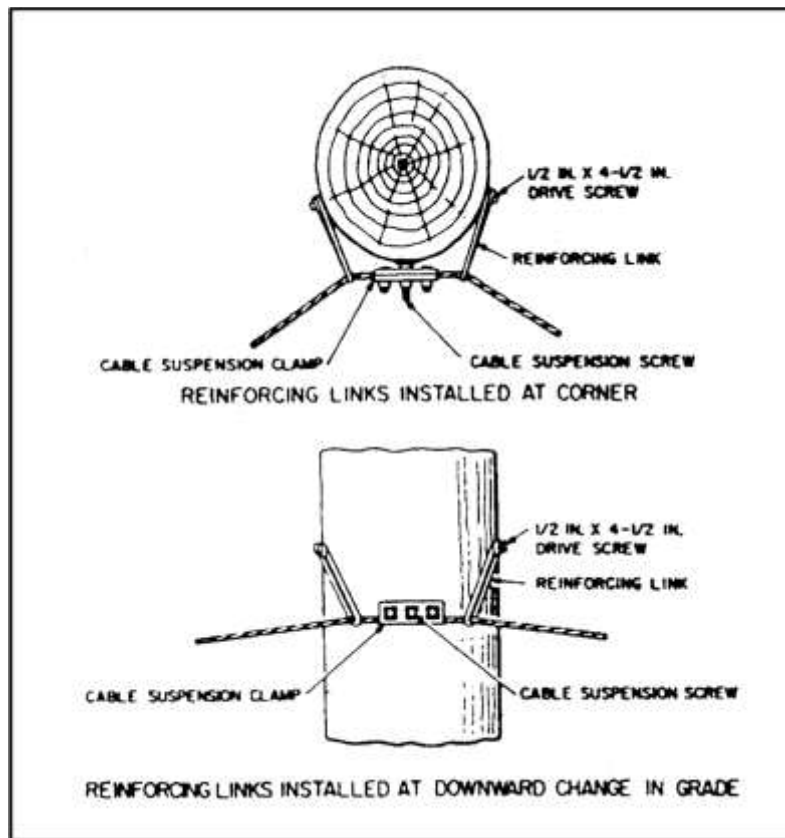
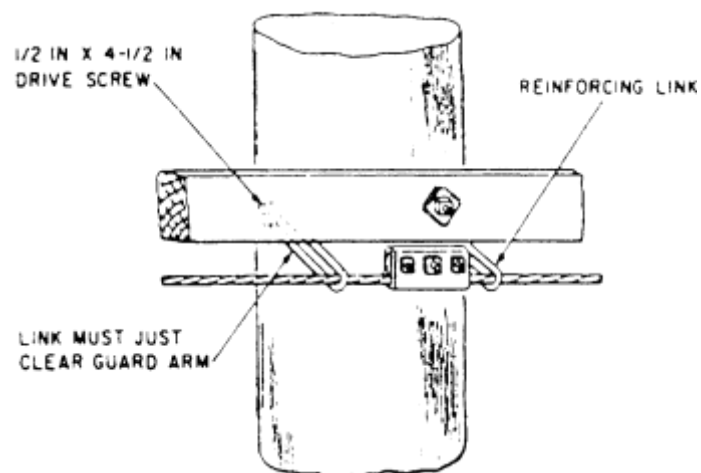
Reinforcing links are required under the following conditions:

- On poles where it is necessary to reinforce the cable-suspension bolt and there is a guard arm, and where, for other reasons, it is impractical to use a reinforcing strap.
- At corners where cable-suspension screws are used and the pull away from the pole is 10 feet or more for 6.6 M or 6 M suspension strand or 5 feet or more for larger strand.

Use S-type reinforcing links where the pole diameter is 7 inches or less at the point of attachment. Use L-type reinforcing links where the pole diameter is more than 7 inches.

When required, place the reinforcing links after the strand has been run out, but *before* it is tensioned so the links will support any corner pull or downward change in grade as the strand is tensioned. See [Figure 5-12](#).

Where a guard arm is used, attach the links as far above the level of the suspension strand as the clearance between the link and the guard arm will permit. An installation of reinforcing links at a guard is shown in [Figure 5-13](#).

**Figure 5-12 Reinforcing Links Installed on Pole****Figure 5-13 Reinforcing Links Installed at Guard Arm Location on Pole**

## 5.7 Table of Hardware for Attaching Suspension Strand

Table 5-3 shows the hardware required to attach 6.6 M, 6 M, and 10 M suspension strands to line and corner poles. Other strand sizes are omitted because of their infrequent use. If a 7/16-inch suspension strand is required, check with the local communications company for the specific type of hardware required.

**Table 5-3 Suspension Strand Hardware for 6.6 M, 6 M, and 10 M Strand**

| Hardware<br>(see caution)                                            | Cable<br>Diameter   | 6 M / 6.6 M Suspension Strand |                             |                             | 10 M Suspension Strand      |                          |                             |
|----------------------------------------------------------------------|---------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------|-----------------------------|
|                                                                      |                     | Pull                          |                             |                             | Pull                        |                          |                             |
|                                                                      |                     | Less Than<br>10 ft            | 10 ft to 50 ft [Note 1]     |                             | Less Than<br>5 ft           | 5 ft to 50 ft [Note 1]   |                             |
|                                                                      |                     |                               | Pull Toward                 | Pull Away                   |                             | Pull Toward              | Pull Away                   |
| Suspension<br>Clamp [Note 2]                                         | All Sizes           | B Cable                       | B Corner                    | B Corner                    | B Cable                     | B Corner                 | B Corner                    |
| Suspension Bolt<br>Size<br>[Note 3]                                  | All Sizes           | 10 M<br>5/8 in                | 16 M<br>3/4 in              | 16 M<br>3/4 in              | 10 M<br>5/8 in              | 16 M<br>3/4 in           | 16 M<br>3/4 in              |
| Washer                                                               | All Sizes           | B Curved                      | E Curved                    | E Curved                    | B Curved                    | E Curved                 | E Curved                    |
| Suspension<br>Clamp Space<br>between washer<br>and clamp [Note<br>4] | 1.6 inch or<br>Less | 1 Nut                         | 2 Nuts                      | 1 Nut                       | 1 Nut                       | 2 Nuts                   | 1 Nut                       |
|                                                                      | Over 1.6<br>inch    | 2 Nuts                        | Pole Strand<br>Connector    | 2 Nuts                      | 2 Nuts                      | Pole Strand<br>Connector | 2 Nuts                      |
| Reinforcing<br>Strap<br>[Note 5]                                     | 1.6 inch or<br>Less | None                          | C                           | None                        | 8 ft                        | Two Cs                   | C                           |
|                                                                      | Over 1.6 inch       | 8 ft                          | C                           | C                           | 8 ft                        | Two Cs                   | C                           |
| Strap<br>Attachment                                                  | .6 inch or<br>Less  | None                          | 1/2×4-1/2 in<br>Drive Screw | None                        | 1/2×4-1/2 in<br>Drive Screw | 5/8-in Bolt              | 1/2×4-1/2 in<br>Drive Screw |
|                                                                      | Over<br>1.6 inch    | 1/2×4-1/2 in<br>Drive Screw   | 5/8-in Bolt                 | 1/2×4-1/2 in<br>Drive Screw | 1/2×4-1/2 in<br>Drive Screw | 5/8-in Bolt              | 1/2×4-1/2 in<br>Drive Screw |

**Note [1]** Where a pull exceeds 50 feet, the strand must be dead-ended and guyed each way.

- [2] At railroad crossings, use a corner clamp if pull exceeds 5 feet.
- [3] When B guy hook is also attached to suspension bolt, guy size determines bolt size.
- [4] Pull of 10 feet or more. If pull is less than 10 feet, use one or two nuts, depending on cable diameter.
- [5] Reinforcing strap required for down pull of 10% or greater.

**! CAUTION ! Only "B" cable-suspension clamps and "B" corner-suspension clamps shall be used with a 6.6 M strand:**

## 5.8 Guy Hooks

Guy hooks are used to terminate suspension strand or guy strand. They are available in two types, “B” and “C”, and in three sizes: 5/8-inch, 3/4-inch and 1-inch. The size of the guy hook is associated with the diameter of the suspension bolt used to secure the guy hook to a pole.

The 5/8-inch size is secured with a 5/8-inch suspension bolt to terminate a 3/8-inch or smaller strand. The 3/4-inch size guy hook is secured with a 3/4-inch suspension bolt to terminate 7/16-inch strand. The 1-inch size guy hook is secured with a 1-inch suspension bolt to terminate 1/2-inch strand.

As shown in [Figure 5-14](#), there are three types of guy hooks:

- One type has an integral spur that digs into the pole to prevent the hook from rotating.
- The second type has a 9/16-inch hole through which a drive screw is driven to prevent the guy hook from rotating.
- The third type, C-type, has a recessed slot to accommodate the head of the A-type suspension bolt and must be used with a thimble eye nut.

[Table 5-4](#) lists the sizes of guy hooks and the bolts used to terminate the various sizes of guy strand.

**Figure 5-14 B- and C-Type Guy Hooks**

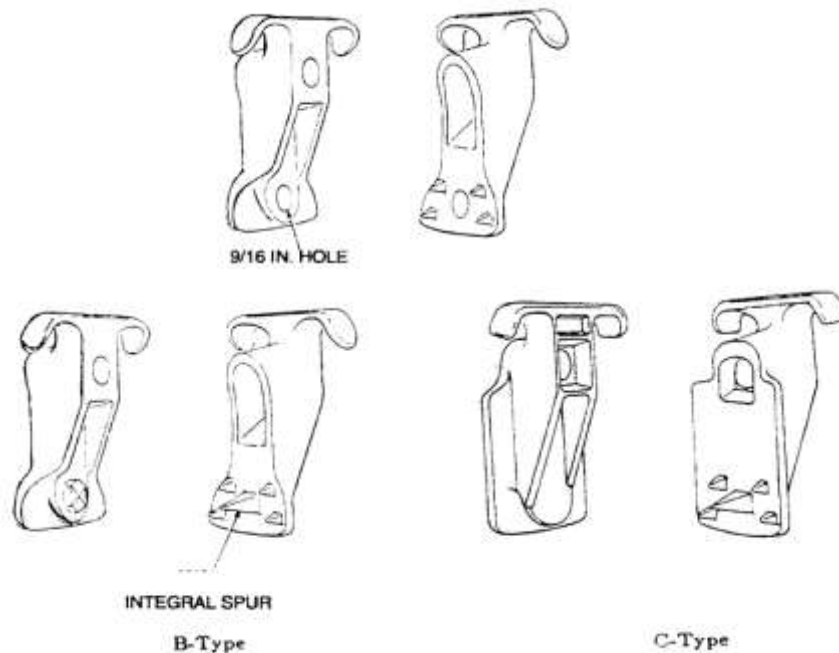
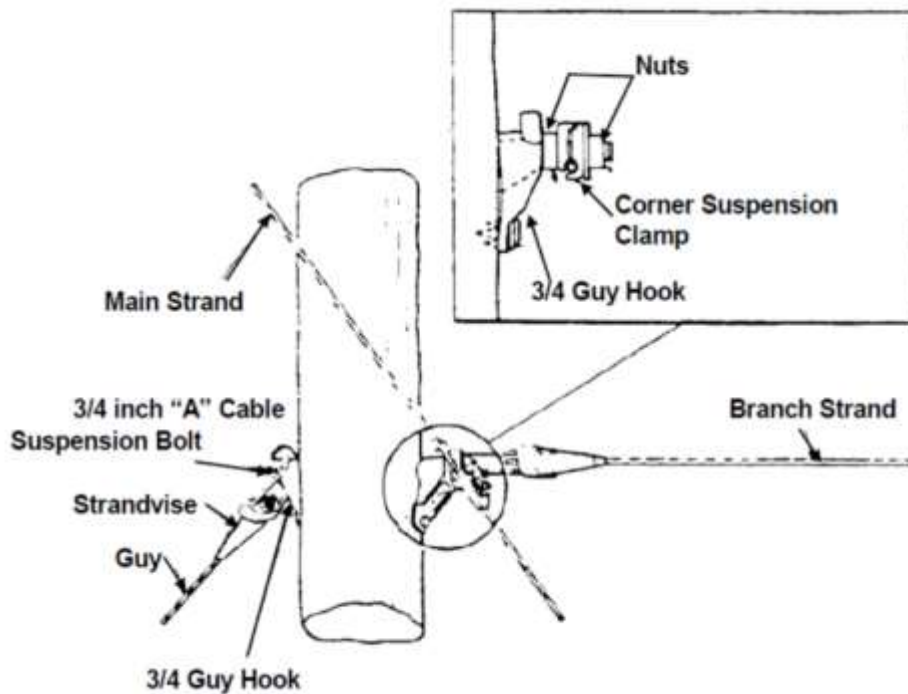


**Table 5-4 Combinations of Guy Hooks and Suspension Bolts for Terminating Guys**

| Maximum Guy Size | Either Type Suspension Bolt | Guy Hook Size |
|------------------|-----------------------------|---------------|
| 3/8-inch         | 5/8-inch                    | 5/8-inch      |
| 7/16-inch        | 3/4-inch                    | 3/4-inch      |
| 1/2-inch         | 1-inch                      | 1-inch        |

The 3/4-inch or 1-inch size guy hooks can be used for branch strand terminations where the main cable and branch cable are on the same side of the pole. The 5/8-inch size cannot be used because its ears will not extend above the cable-suspension clamp. The guy hook can be attached to the pole with the same bolt that supports the suspension strand for the main cable (Figure 5-15).

**Figure 5-15 Branch Strand Termination - 6.6 M or 6 M Main Strand**

Two guy hooks, when placed as shown in Figure 5-16, may be used to receive a suspension strand and a guy strand. The size of the suspension bolt and guy hook to be used is based on the size of the suspension strand or guy strand, whichever is larger. For strands 10 M and smaller, use a 5/8-

inch suspension bolt, either type, and a 5/8-inch guy hook. For 16 M strands, use a 3/4-inch guy hook. For a 25 M strand, use a 1-inch suspension bolt and a 1-inch size guy hook.

For pole-to-pole guys, invert the lower guy hook so the load is on the shoulder of the guy hook (Figure 5-17).

**Figure 5-16 Installed Guy Hooks**

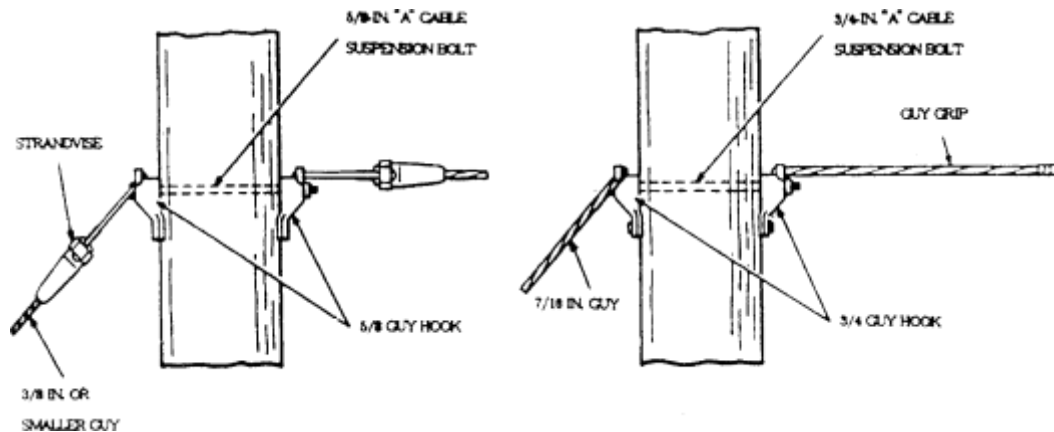
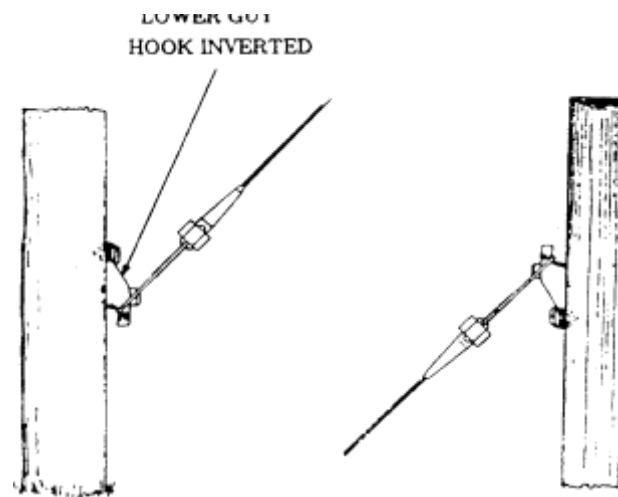


**Figure 5-17 Guy Hooks Installed - Pole-to-Pole Guy**





## 5.9 Thimble Eye Bolts

There are two types of thimble eye bolts ([Figure 5-18](#)): *angled* (bent) and *straight*. Angled thimble eye bolts are used to terminate guy strand when the lead-over-height ratio is less than 1-1/4 inches. (See [Section 6.3](#) for the calculation method of lead-over-height ratio.) Straight thimble eye bolts are used when the ratio is greater than 1-1/4 inches. Thimble eye bolts can be used to terminate all sizes of guy strand and, when equipped with an eye nut, they can be used for dead-ending suspension strands of all sizes. [Figure 5-19](#) shows the hardware arrangement for terminating suspension strand on eye nuts. [Table 5-5](#) shows the hardware required to dead-end guys when the lead-over-height ratio is less than 1-1/4 inches. [Table 5-6](#) shows the hardware required when the lead-over-height ratio is greater than 1-1/4 inches.

Hardware selection is based on the size of the suspension strand or guy strand, whichever is larger.

**Figure 5-18 Thimble Eye Bolts**

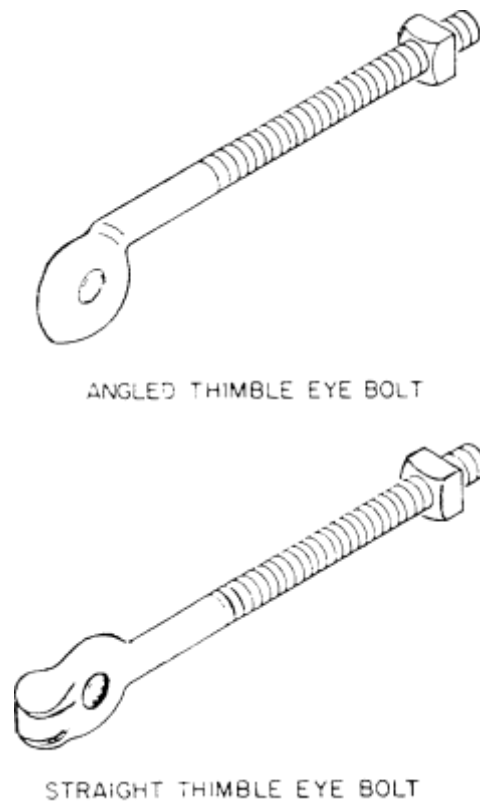
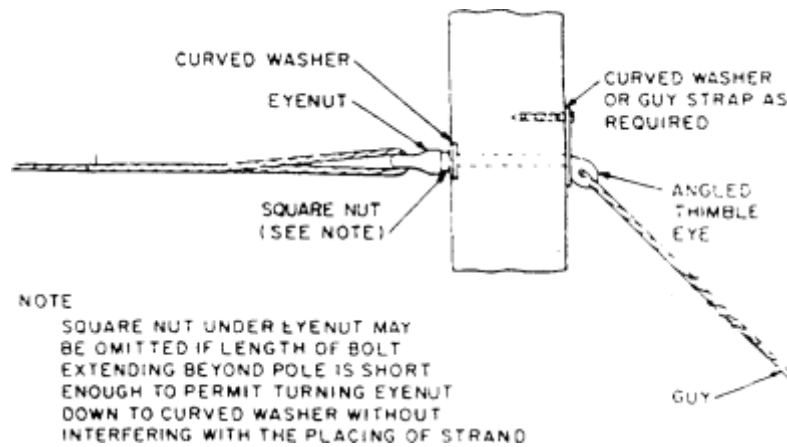


**Figure 5-19 Installation of Angled (Bent) Thimble Eye Bolt****Table 5-5 Hardware for Terminating Strands – Lead-Over-Height Ratio of 1-1/4**

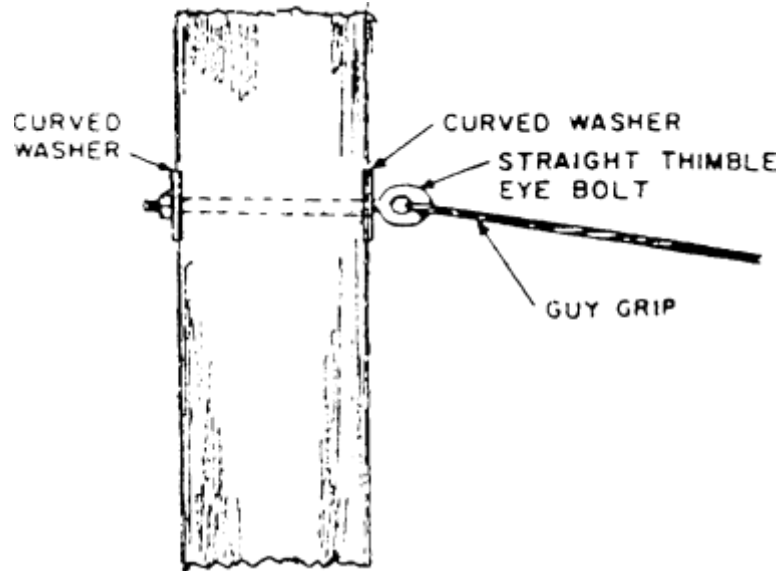
| Size of Larger Strand | Size of Angle Thimble Eye Bolt (Inches) | Size of Washer or Guy Strap at Eye of Bolt (Inches) | Size of Curved Washer at Threaded End of Bolt (Inches) |
|-----------------------|-----------------------------------------|-----------------------------------------------------|--------------------------------------------------------|
| 1/4 inch              | 5/8 inch                                | Curved Washers<br>3-1/8 x 3-1/4 x 1/4 inch          | 3-1/8 x 3-7/4 x 1/4 inch<br>3/4 inch hole              |
| 5/16 inch             | 5/8 inch                                | Curved Washers<br>3-1/8 x 3-1/4 x 1/4 inch          | 3-1/8 x 3-7/4 x 1/4 inch<br>3/4 inch hole              |
| 3/8 inch              | 5/8 inch                                | Guy Strap<br>9 x 2-1/2 x 5/16 inch                  | 3-1/8 x 3-1/4 x 1/4 inch<br>3/4 inch hole              |
| 7/16 inch             | 3/4 inch                                | Guy Strap<br>9 x 2-1/2 x 5/16 inch                  | 3-3/8 x 3-1/2 x 3/8 inch<br>7/8 inch hole              |
| 1/2 inch              | 1 inch                                  | Guy Strap<br>7 x 4 x 5/16 inch                      | 3-3/8 x 3-1/2 x 3/8 inch<br>1-1/16 inch hole           |

**Table 5-6 Hardware for Terminating Strands Where the Lead-Over-Height Ratio Is Greater Than 1-1/4**

| Size of Larger Strand | Size of Straight Thimble Eye Bolt (inches) | Size of Curved Washer at Each End of Bolt (Inches) |
|-----------------------|--------------------------------------------|----------------------------------------------------|
| 1/4 inch              | 5/8 inch                                   | 3-1/8 x 3-1/4 x 1/4 inch<br>3/4 inch hole          |
| 5/16 inch             | 5/8 inch                                   | 3-1/8 x 3-1/4 x 1/4 inch<br>3/4 inch hole          |
| 3/8 inch              | 5/8 inch                                   | 3-1/8 x 3-1/4 x 1/4 inch<br>3/4 inch hole          |
| 7/16 inch             | 3/4 inch                                   | 3-3/8 x 3-1/2 x 3/8 inch<br>7/8 inch hole          |
| 1/2 inch              | 1 inch                                     | 3-3/8 x 3-1/2 x 3/8 inch<br>1-1/16 inch hole       |

Figure 5-20 shows a straight thimble eye bolt installation and its associated hardware.

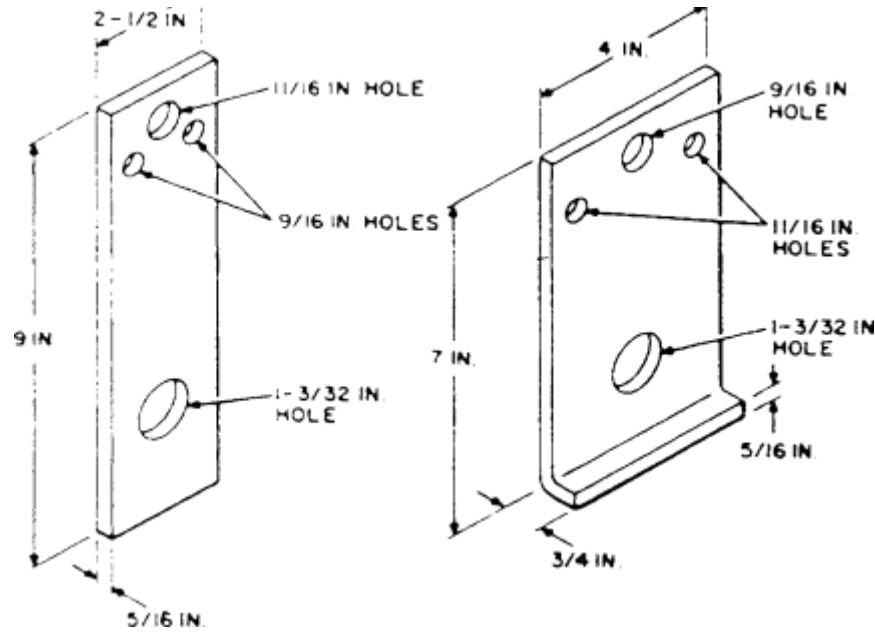
**Figure 5-20 Installation of a Straight Thimble Eye Bolt**



## 5.10 Guy Straps

Guy straps for reinforcing thimble eye bolts are available in two sizes. The guy straps are galvanized steel and are shown in [Figure 5-21](#).

**Figure 5-21 Guy Straps**



A guy strap must be used with an eyebolt when the guy strand is 10 M or larger and the lead-over-height ratio is 1-1/4 or less. The guy straps may be attached to the pole with two 1/2-inch drive screws or with a 5/8-inch suspension bolt located above the eye bolt. If the distance from the drive screws or suspension bolt (whichever is used) and the pole top will be less than 16 inches, turn the strap so the drive screws or suspension bolt will be below the thimble eye bolt. Refer to [Table 5-5](#) for guy strap applications.

## 5.11 Guy Clamps

Guy clamps are available in three sizes: 1 bolt, 2 bolt, and 3 bolt. With the proper size selection and the proper number of clamps, they can be used to dead-end all sizes of strand. The nominal dimensions and types of clamps are listed in [Table 5-7](#).

**Table 5-7 Dimensions and Types of Guy Clamps**

| Clamp Size | Length      | Width        | Type   |
|------------|-------------|--------------|--------|
| 1-Bolt     | 1-7/16 inch | 1-9/16 inch  | Medium |
| 2-Bolt     | 3-3/8 inch  | 1-9/16 inch  | Medium |
| 3-Bolt     | 6 inches    | 1-21/32 inch | Heavy  |

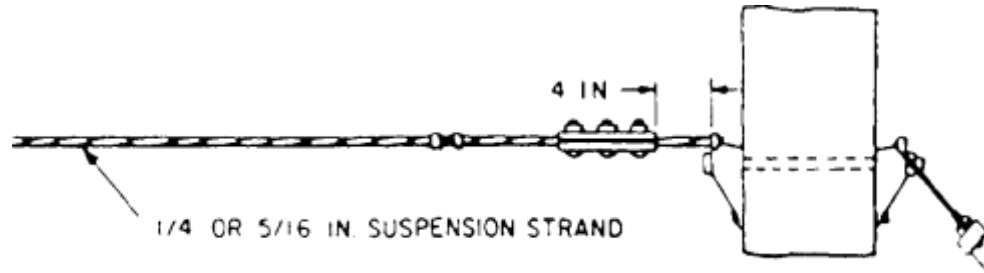
The number and types of clamps that must be used when terminating various sizes of suspension strand or guy strand are listed in [Table 5-8](#).

**Table 5-8 Number and Type of Clamps Used to Terminate Guy Strand**

| Size of Strand in Inches | Size of Strand | Number and Type of Guy Clamps |
|--------------------------|----------------|-------------------------------|
| 3/16                     | 2.2 M          | One x 1-Bolt Clamp            |
| 1/4                      | 4.4 M          | One x 2-Bolt Clamp            |
| 5/16                     | 6 M            | One x 3-Bolt Clamp            |
| 3/8                      | 10 M           | One x 3-Bolt Clamp            |
| 7/16                     | 16 M           | Two x 3-Bolt Clamps           |
| 1/2                      | 25 M           | Three x 3-Bolt Clamps         |

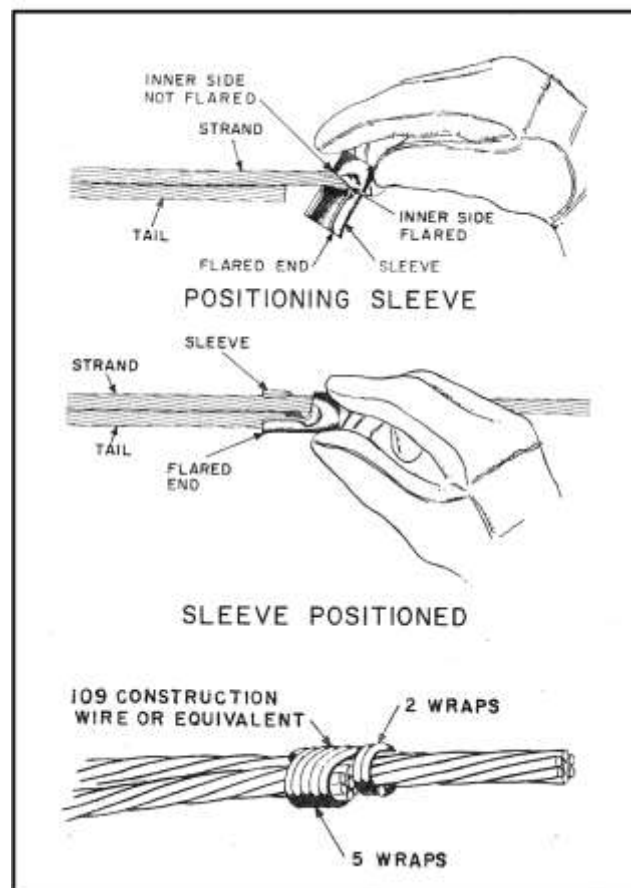
Figure 5-22 shows the use of a guy clamp to dead-end a suspension strand.

**Figure 5-22 Arrangement of Guy Clamp**



The tail of the guy must be served with a serving sleeve or with steel construction wire, as illustrated in Figure 5-23.

**Figure 5-23 Serving the Guy Tail**



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**Note:** Serving sleeves (also referred to as clips) are the preferred method, with 2 sleeves necessary for larger guy wire sizes such as 16 M and above.

**Note:** The traditional wire for this purpose, known as “109 construction wire,” is a solid galvanized steel tying wire made from a mild annealed steel of 60 kpsi tensile strength with a zinc galvanizing covering of 0.8 oz/ft<sup>2</sup> (ASTM A90). The wire has a nominal diameter of 0.109 inch (min. 0.105---max. 0.112), with a minimum breaking strength of 457 lb. Other equivalent tying wires may be used that have sufficient strength, adequate corrosion resistance, and are of good quality that meet relevant industry standards.

## 5.12 Guy Grips (“B” Strand Grips)

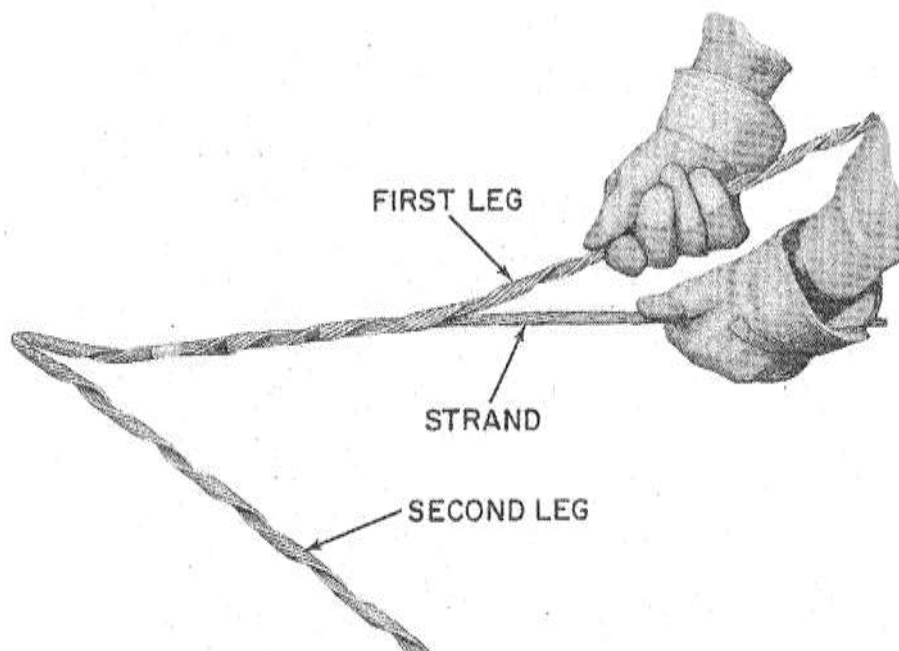
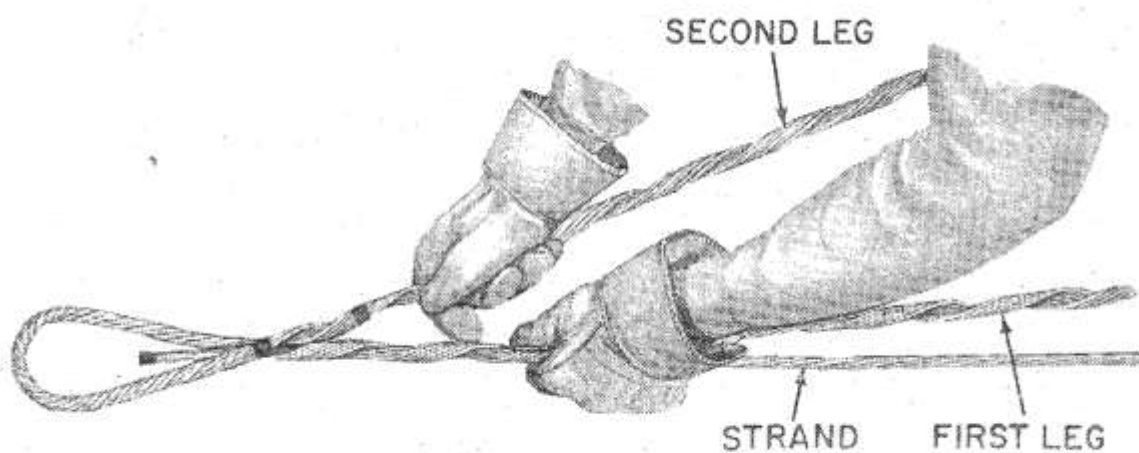
Guy grips, sometimes referred to as strand grips, may be used to terminate guy strand and suspension strand on guy hooks, strain insulators, and eye-type hardware. The grips are made of spirally-formed high-strength steel wires and are available in sizes corresponding to the outside diameters of standard galvanized strand. Refer to [Table 5-9](#).

**Table 5-9 Dimensions and Color Markings of “B” Strand Grips**

| Strand Size | Strand Diameter (Inches) | Overall Lengths (Inches) | Crossover Points Color Markings |
|-------------|--------------------------|--------------------------|---------------------------------|
| 2.2 M       | 3/16                     | 20                       | Red                             |
| 6 M         | 5/16                     | 31                       | Black                           |
| 6.6 M       | 1/4                      | 25                       | Yellow                          |
| 10 M        | 3/8                      | 35                       | Orange                          |
| 16 M        | 7/16                     | 38                       | Green                           |
| 25 M        | 1/2                      | 50                       | Blue                            |

**! CAUTION ! “B” strand grips shall not be reused after initial installation.**

[Figure 5-24](#) and [Figure 5-25](#) show how the guy grip is wrapped around the strand.

**Figure 5-25 Applying First Leg****Figure 5-24 Applying Second Leg**

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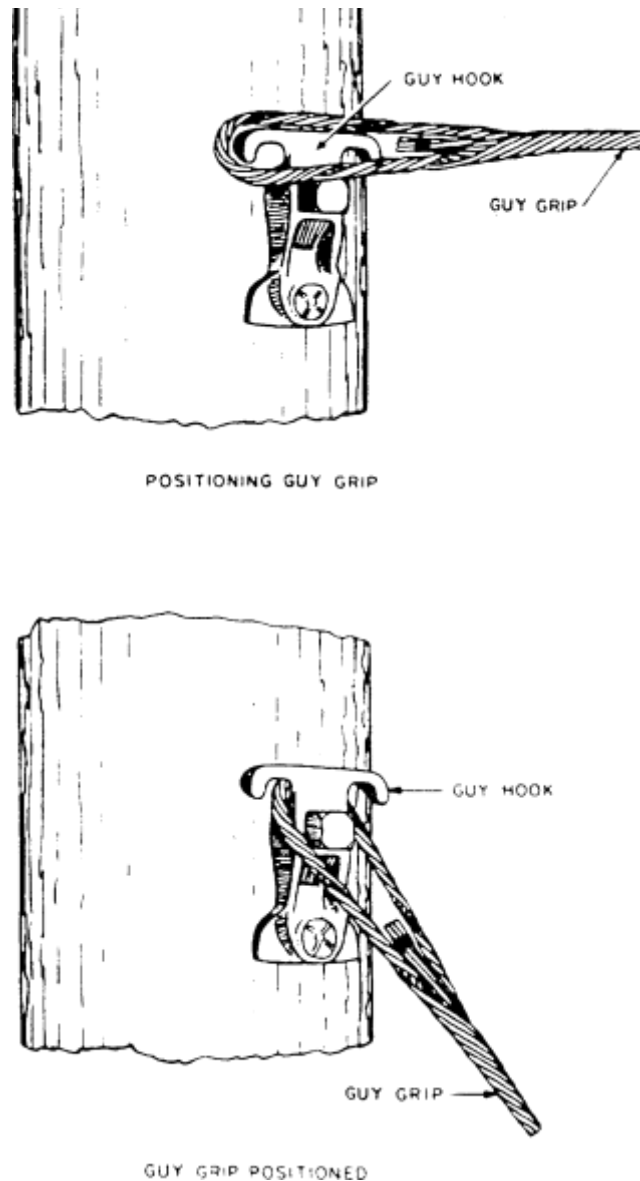
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Figure 5-26 shows how the guy grip, when attached to a guy strand, is installed over a guy hook.

**Figure 5-26 Guy Installed Using Guy Hooks and Guy Grip**



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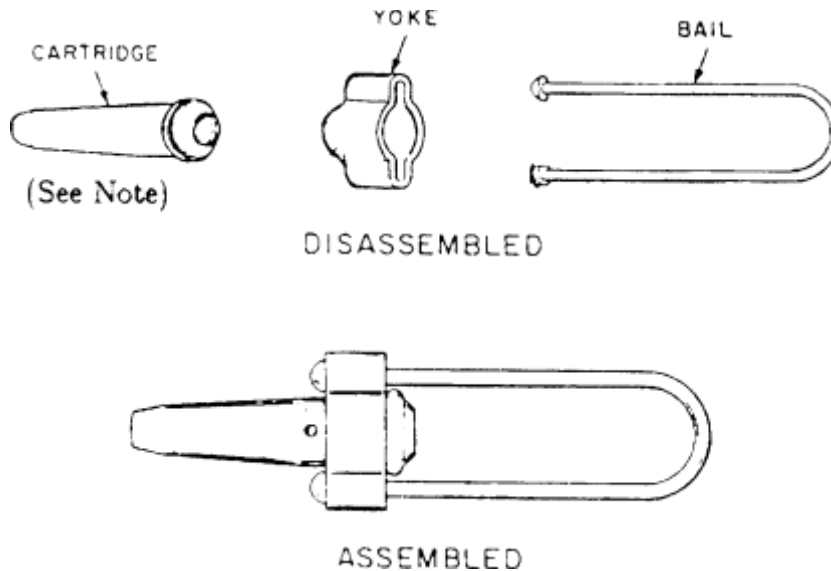
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### 5.13 Strandvises

Strandvises are available in sizes corresponding to galvanized suspension strand. The strandvise consists of three parts: a cartridge, a yoke, and a bail (Figure 5-27). The bail and the yoke may be reused, but not the cartridge. There are two sizes of bail: long and short. The long bail is designed solely for use with strain insulators. The short bail is used on eye-type hardware and guy hooks.

**Figure 5-27 Strandvise**



Strandvises can be safe and durable providing the correct size and both strandvise and strand are clean and smooth. To help ensure that the correctly sized strandvise products are matched with the strand sizes, several manufacturers use color coded plugs, as shown above.

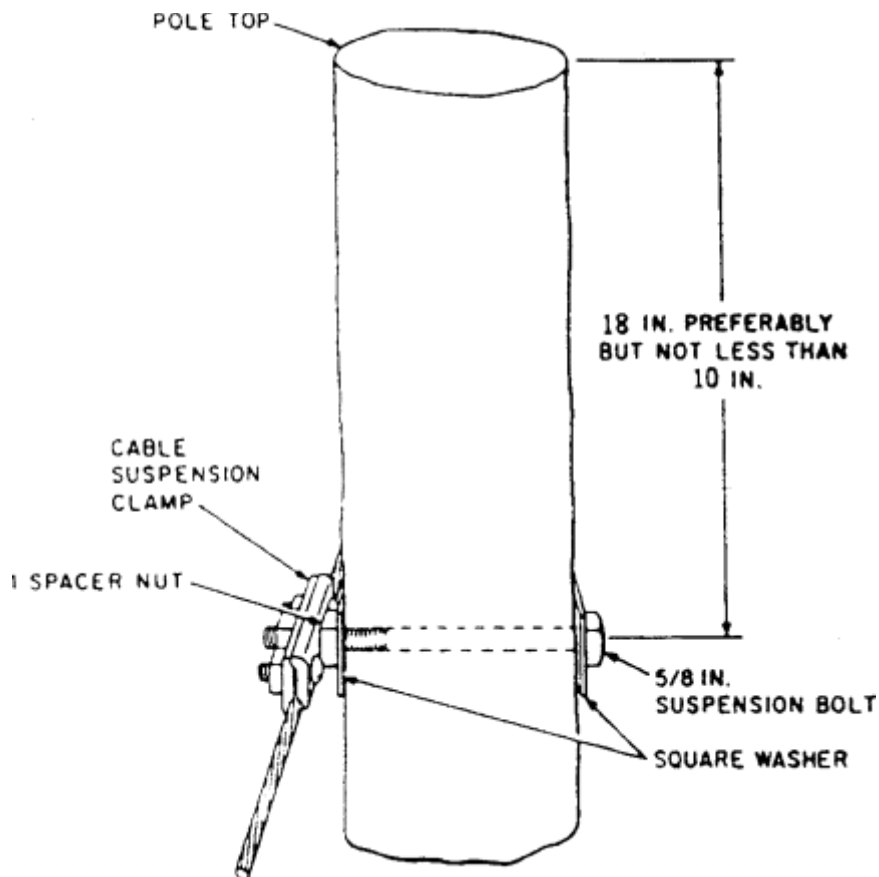
**Note:** The strandvise is not recommended for use on corrosion-resistant strand or in seacoast (marine) locations where extreme conditions of exposure to salt spray or salt fog may be encountered. When used on existing strand, any rust that may have developed must be removed with emery cloth. The strandvise is not recommended for use on strand that has deteriorated to a point where no galvanizing remains, because the strandvise will loosen as a result of further rust formation on the strand.

## 5.14 Pole Attachment Illustrations

The figures in this section show how to place the proper hardware when making attachments in various situations on poles carrying communications cables and owned by the communications company.

Figure 5-28, Figure 5-29, and Figure 5-30 show the attachments on in-line poles.

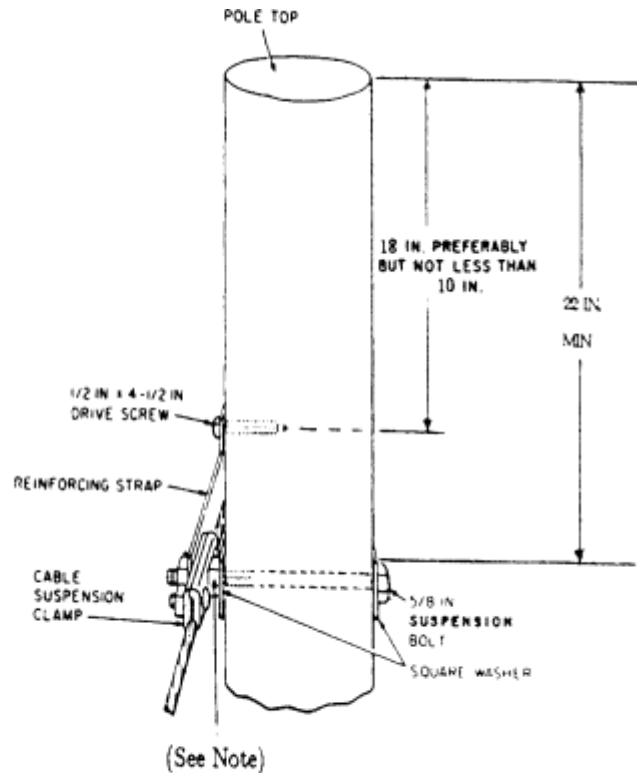
**Figure 5-28 Pole Attachment for 6.6 M or 6 M Suspension Strand Without Reinforcing Strap**



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**Figure 5-29 Pole Attachment With Reinforcing Strap  
Attached With Drive Screw**



**Note:** Use one or two spacer nuts depending on the cable diameter.  
Cable larger than 1.6 inch diameter requires two spacer nuts.

**Figure 5-30 Pole Attachment With Reinforcing Strap Attached With Suspension Bolt**

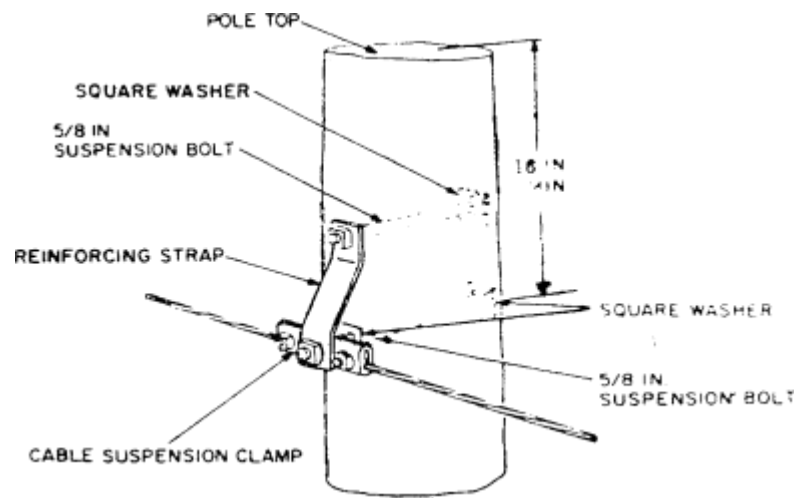


Figure 5-31 shows the hardware arrangement where the pull is away from the pole and a guy is attached to a guy hook. The determination of correct bolt size should be based on the size of the strand or guy, whichever is larger.

**Figure 5-31 6.6 M or 6 M Suspension Strand – Pull Away From Pole – 10 Feet or More**

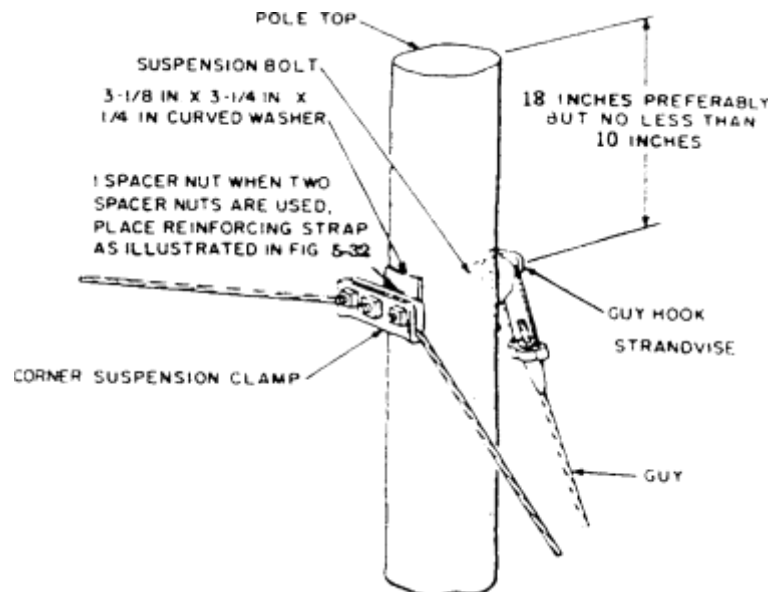
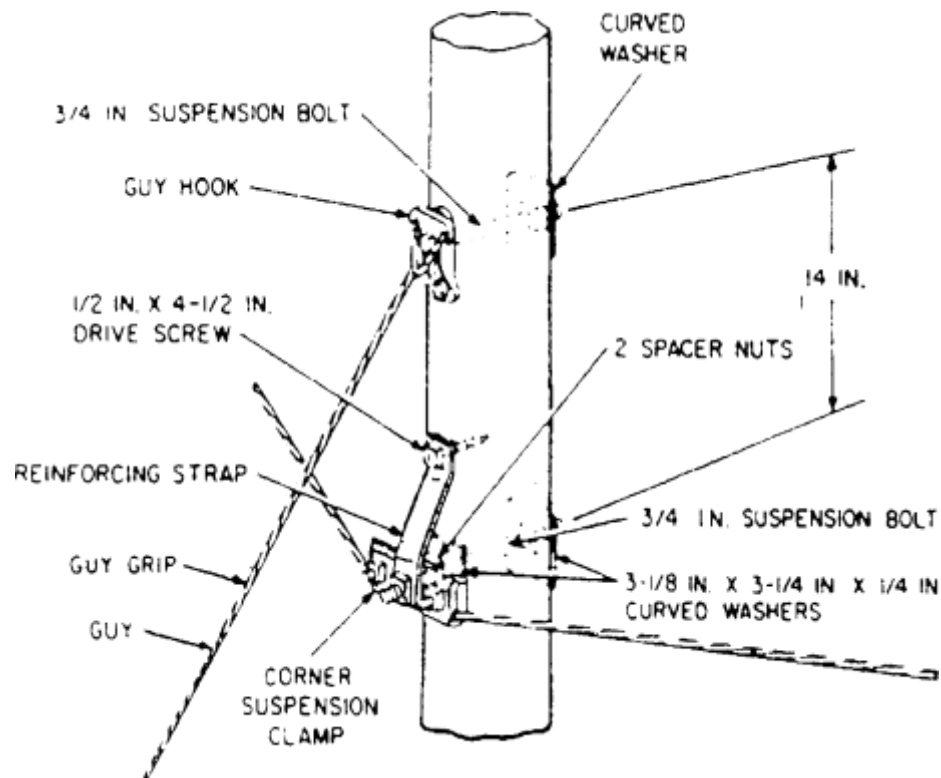


Figure 5-32 shows the hardware arrangement for cable sizes less than 1.6 inch in diameter where 6.6 M or 6 M strand is used and the pull toward the pole is greater than 10 feet.

**Figure 5-32 6.6 M or 6 M Suspension Strand With Reinforcing Strap – Pull Toward Pole – 10 Feet or More**



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## 5.15 Non-Wood Poles

Current interest for using alternative non-wood pole materials is driven by environmental concerns around wood preservatives, as well as some favorable economic and performance factors such as low prices for steel, lightweight handling characteristics of fiberglass poles, and corrosion resistance of concrete poles in swampy, coastal areas. Following a short description of the main non-wood pole types, this section contains general observations and guidelines for attachment hardware for non-wood poles.

### 5.15.1 Concrete Poles

The various designs for concrete poles include tapered structures and round poles made of:

- Solid Concrete
- Pre-Stressed Concrete: Spun-Cast
- Pre-Stressed Concrete: Statically Cast
- Hybrid – Concrete and Steel Poles.

The most widespread use of concrete poles has occurred in marine environments and coastal zones where more stringent corrosion resistance is required to reduce the impact of sea water, salt fog and corrosive soil conditions (e.g., marsh) on hardware and equipment. The more usual pole designs include square and round concrete poles with uniform taper from top to bottom (butt). Square poles can be easier to cast and thereby be cheaper than rounded or other design shapes. The spun cast poles tend to be lighter and stronger than static cast concrete poles.

### 5.15.2 Steel Poles

Tubular steel poles are typically made from 11-gauge galvanized steel with thicker 10- or 7-gauge materials used for some taller poles because of their higher strength and rigidity. For tall tower type structures, 5-gauge material is used. Any steel poles used should meet industry specifications such as TIA/EIA-222, *Structural Standards for Steel*; and TIA/EIA-222-F, *Structural Standards for Steel Antenna Towers and Antenna Supporting Structures*, or an equivalent requirement set to help ensure a strong and good quality pole is being used. Steel poles can be preferred by power companies because of initial cost considerations (lower material and installation labor cost than comparable wood pole), particularly if taller poles are required for enhanced clearances and longer span requirements.

### 5.15.3 Fiberglass or FRC Poles

Fiberglass or Fiber Reinforced Composite (FRC) poles cover a family of the pole materials that combine fiberglass strength members with cross-linked

polyester resins and a variety of chemical additives to produce a lightweight, weather-resistant structure. The fiberglass filaments can be wound, placarded or centrifugally cast to produce hollow tapered tubes. All these processes can produce strong poles.

A wide variety of round, tapered, square and shapes are possible depending on the mold shapes and dies used in the manufacturing process. FRC poles are hollow and similar to the tubular steel poles with fiberglass typical thicknesses of  $\frac{1}{4}$  to  $\frac{1}{2}$ -inch and an outer thin (1-2 mils) polyurethane coating.

Fiberglass poles are particularly preferred for light duty applications (e.g., flag poles) because of their very light weight and easy installation. For the heavier applications of telecommunications and power distribution plant, fiberglass poles have some similarity to tubular steel poles (i.e., slender wall thickness), but without the limitations associated with a conductive metallic pole material.

#### 5.15.4 Hardware for Non-Wood Poles

Since non-wood poles have distinctly different physical and handling characteristics than traditional wooden poles, it is necessary to ensure the availability and reliability of hardware and tools that may be necessary to complete the installation and maintenance of such a pole, as well as the telecommunication and electric power attachments.

This will include possible items such as steps for craftpersons, guy wire hooks, cross-arms and support struts, power insulators, equipment (e.g., transformers) and appropriate clamps and brackets for supporting cables, messengers, and service wires at the pole. Any special screws, bolts or washers required for attaching brackets, hooks, ground wires, conduits, name plates, etc., must also be available with all necessary installation and maintenance instructions and product information.

The inappropriate use of wood pole line hardware on non-wood poles can have a large negative effect on the reliability of the telecommunications plant and the safety of the technicians climbing and working in the aerial plant.

Table 5-10 lists the basic types of attachment hardware that are needed for any pole structure that is to carry and support aerial telecommunications plant. The items in this table are derived from the earlier parts of this Chapter 5, insight from Chapters 6 through 10, and industry experience.

For information on functional performance requirements of pole attachments, in general, as well as guidelines for non-wood poles in particular, refer to the following Ericsson - NIS documents:

- GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*



- GR-3159-CORE, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles.*

The test conditions used in the GRs to evaluate the products overstress the products relative to the expected design and operational stresses to which the hardware shall be exposed so as to help predict long term performance . Since the design stresses includes added safety factors for the expected loading, the stresses experienced in normal operational will be lower.

### 5.15.5 Guys

Down guys are attached to the pole by applying downward forces at various angles, most typically between 20-45 degrees to the pole. The guy hook hardware has spurs or prongs that dig into wood poles and provide supplementary bonding and stability for the guy wire/guy hook attachment.

In non-wood poles, such spurs and prongs are not effective since the concrete, steel and fiberglass materials are too hard, and down forces will translate into torques that place high stress on the bottom edge of the guy hook, resulting in damage to the pole surface and inappropriate point stress concentration on one section of the attachment hardware.

Smooth hardware with rounded plates to conform to the pole surface are needed matching the curvature of the pole. For FRC poles, self-tapping screws (not driven fasteners like nails or staples) are required.

**Table 5-10 Hardware Types and Applications**

| Hardware Type                    | Function                                                                                  | Non-Wood Poles                                                                                                                                                                                       |                                                                |                  |
|----------------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|------------------|
|                                  |                                                                                           | Fiberglass (Tubular)                                                                                                                                                                                 | Steel (Tubular)                                                | Concrete (Solid) |
| Suspension Clamp                 | Supports strand on pole                                                                   | Can be used. It is recommended that through-bolts be used to attach the clamp to pole.                                                                                                               |                                                                | Note [1]         |
| Corner-Suspension Clamp          | Supports strand on pole where pull is 10-50+ feet                                         | Can be used. It is recommended that through-bolts be used to attach the clamp to pole.                                                                                                               |                                                                | Note [1]         |
| Cable Clamp (self-support cable) | Secures cable or jacketed strand                                                          | Can be used. It is recommended that through-bolts be used to attach the clamp to pole.                                                                                                               |                                                                | Note [1]         |
| Suspension Bolts (A and B Type)  | Secure suspension and other clamps to pole                                                | Can be used although bolts should be used with the larger size curved washers to distribute load.                                                                                                    |                                                                | Note [1]         |
| Suspension Screws                | Driven screw to secure suspension and other clamps to pole                                | Do not use                                                                                                                                                                                           | Do not use                                                     | Do not use       |
| Reinforcing or Support Straps    | Prevent the bending of suspension bolts or screws that support suspension clamps hardware | Only use 10-inch or longer straps                                                                                                                                                                    | Only use 10-inch or longer straps                              | Do not use       |
| Drive Screws                     | Driven screw to secure strap or other support hardware to pole                            | Do not use                                                                                                                                                                                           | Do not use                                                     | Do not use       |
| Reinforcing Links (S and L Type) | Alternative reinforcing hardware where support straps are not practical                   | Do not use, since drive screws are required to attach to pole.                                                                                                                                       | Avoid use, since reliability of screw attachment is uncertain. | Do not use       |
| Guy Hooks (B and C Type)         | Terminate strand or guy strand                                                            | Guy hooks with spurs should not be used since spurs are designed to dig into wood and will not work well on other materials.<br><br>It is recommended that through-bolts be used to attach guy hook. |                                                                | Note [1]         |

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| Hardware Type                                              | Function                                                                                       | Non-Wood Poles                                                                        |                    |                     |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------|---------------------|
|                                                            |                                                                                                | Fiberglass<br>(Tubular)                                                               | Steel<br>(Tubular) | Concrete<br>(Solid) |
| Thimble Eye Bolts<br>(Angled and Straight)                 | Terminate guy strand                                                                           | Can be used as an alternative to guy hooks with spurs.                                |                    | Note [1]            |
| Guy Straps                                                 | Reinforcing thimble eye bolts                                                                  | The longer (9 inch or longer) guy straps preferred.                                   |                    | Note [1]            |
| Pole Flanges                                               | Attachment point for iron pipe to wood pole in sidewalk anchor guy arrangement                 | Do not use if drive screws are used to attach topole.                                 |                    | Note [1]            |
| Guy Clamps<br>(1-, 2-, and 3-Bolt Types)                   | Terminate strand and guy strand                                                                | Can be used with all pole types since hardware item is not directly attached to pole. |                    |                     |
| Guy Grips ("B" Strand Grips)                               | Terminate guy or suspension strands on guy hooks, strain insulators and eye type hardware      | Can be used with all pole types since hardware item is not directly attached to pole. |                    |                     |
| Strandvises                                                | Used to terminate aerial support strand messenger, and at the top and bottom ends of down guys | Can be used with all pole types since hardware item is not directly attached to pole. |                    |                     |
| Guy Strain Insulators                                      | For elimination of power cross hazards and metallic corrosion risks in specific locations      | Can be used with all pole types since hardware item is not directly attached to pole. |                    |                     |
| Anchors and Guy Rods - Expanding, Screw and Toggle Anchors | To provide physical support and balance load on poles                                          | Can be used with all pole types since hardware item is not directly attached to pole. |                    |                     |
| Bonding/Grounding Connectors                               | Support screws/staples for attaching grounding/ bonding wire to pole                           | Screws only.<br><br>Driven fasteners or staples should not be used.                   |                    |                     |
|                                                            | Low resistance connector for attachment to MGN                                                 |                                                                                       |                    |                     |
| Banded Straps                                              | Metallic band for attachment to concrete and steel poles                                       | Can be used (see table Notes below and <a href="#">Section 5.15.8</a> )               |                    |                     |

**Note [1]** Since on-site drilling of concrete poles for through-bolts is not feasible, clamps will need to be attached with banded products. The long-term reliability of banded attachments is unknown at present.

**Note [2]** Early version of steel bands with aluminum brackets failed because of overstressing of the steel band and concentrations of high

stress in the crevices or creases adjacent to the bracket. Dissimilar metal galvanic corrosion occurred with early (1980s) band products. Any banded attachments need to maintain their attachment grip over many years of cyclic day/night all-weather stresses. The chief problem is how to obtain maximum initial tension without overstressing the metallic band of the band and straining the metal material into its in-elastic zone where slow relaxation and creep behavior will lead to a premature failure of the band. With the wide diurnal and seasonal temperature swings expected for climates across the country, the repeated day/night cycles can induce significant differential expansion and contraction behavior between poles and hardware, as well as between different metal components of the hardware.

**Note** [3] Saddle brackets and flat faced hardware can be used to achieve effective, strong and reliable bonds to the pole; particularly if the pole is both tapered and has polygonic cross-section. However, the interdependencies between pole material, pole shape, band hardware shape, design and materials will require that any candidate banded hardware needs to meet stringent and full stress/strain criteria under exposure conditions.

#### 5.15.6 Holes and Drilling

Pre-drilled holes can only be a benefit for non-wood poles if the holes are at the correct height and position for the attachment of cables, apparatus and other aerial plant items. Since many strands or guys will approach the pole at different and considerable angles, to use pre-drilled holes would require the pole placement crew to rotate and orient the pole correctly in order to accommodate the hardware to be used.

Unless there are multiple pre-drilled holes in a pole, it is unlikely that the different pulls on the pole can be properly balanced. Repeated drilling of the non-wood tubular poles is not a recommended routine practice since too many holes, or holes that are too close together, on a tubular pole can introduce stress concentration points on the pole surface and may weaken the attachment point as well as the structural integrity of the pole.

The abrasive nature of fiberglass materials requires carbide-tipped bits to be used in drills or the holes to be cut with a carbide-tipped hole saw. Standard high-speed steel twist drill bits can be used but will begin to dull after a relatively small number of holes are drilled. Wood drill bits will be ruined after only a few drillings (5 to 10).

#### 5.15.7 Lag Screws and Support Straps

Some suppliers of non-wood poles suggest that their poles can use the same hardware as wood poles. This may be true in some cases; however, there are times this logic does not hold true to field practices and deployment needs. For example, consider the hanger and support strap configurations needed for cases of heavy strand and where certain types of pulls and strains are

placed on the attachment hardware because of cable dimensions and weight.

Either (a) the placement of 10 M strand and greater, or (b) if cables have circumferences greater than 1¼-inch (regardless of strand size), requires that a spacer be used on the bolt between the inside nut and the cable hanger. Many times a technician will simply use another nut to provide the additional space. This space is needed to keep the cable from rubbing against the pole during periods of expansion and contraction caused by changes in weather and the effect of winds. Since the cable weight is further out on the bolt, a supporting strap is required to prevent unbalanced stress on the main bolt.

A typical supporting strap for straight line setups is just under 6 inches long. When the strap is set in position, it is closer than 5 inches from where the pole was drilled for the bolt. A 5/8-inch lag screw is used to secure it to the pole. In non-wood pole cases, a lag screw could not be used and instead another hole would be needed for a bolt to secure the supporting strap. This means that a longer strap of 10+ inches is needed to give sufficient room between pole holes on a fiberglass or steel tubular pole. This also means that more space is required on the pole just to accommodate the hardware changes created by the design of the alternative non-wood pole or else the long-term reliability of the pole attachment is compromised. The hardware arrangement described above is only one of many common hardware arrangements that would need to be modified to accommodate non-wood poles and retain high-quality plant.

Attachments using lag bolts, teeth, nails and staples are not advisable for fiberglass poles. Through-bolts are used instead of lag bolts for maximum bonding to the pole and to avoid loosening of hardware. These must be supplemented with square curved washers to maximize bonding and gripping force.

Looking at general fastener hardware, those more suitable for fiberglass poles would be those using self-drilling or self-tapping screws or bolts. During the placement of the screw or bolt, the fiberglass material will deform and yield around the thread. After the screw/bolt is placed into the pole, there may be a detectable amount of deformation around the penetration point. Since the fiberglass is a thermoset material, and this deformation strain is expected to be in the elastic regime of the material, this material behavior will help grip the screw or bolt. Even with the self-tapping or self-drilling fasteners, there remain some concerns as to degradation in the strength of the attachment over time (fatigue).

### 5.15.8 Banded Hardware Attachments

The use of banded hardware is often advocated to avoid the problems associated with drilling of non-wood poles and the potential failure of bolts because of loose fittings. The thin walls of the FRC and steel poles may not provide sufficient mechanical bonding between fasteners and pole. Abrasion

and wear around the hole can develop under the diurnal and wind-induced mechanical stresses. For concrete poles, the concrete around a drilled hole can crack and, under the influence of freeze/thaw cycles and environmental conditions, loosen or disengage the threaded fasteners (screws, bolts). The action of drilling can also damage the pole surfaces and lead to a point of failure at some later time.

Whichever banded hardware product is used, it will need to address failure modes such as those that occurred with these field and test failures:

- Steel bands with aluminum brackets failed because of:
  - Over-stressing of the steel band, resulting in high stress concentrations in the crevice/creases adjacent to the bracket
  - Galvanic corrosion around the dissimilar metals interface.
- Slippage/loosening of bands resulting from:
  - Differential thermal expansion/contraction motions during day/night cycling as well as
  - Cyclic mechanical stresses induced by the variable wind loads on the attachment line or equipment
  - Creep under the environmental vibration forces experienced during earthquake testing for cabinets and closures
  - Metallic bands being too narrow and thin to enable a strong mechanical bond to pole surface.

For round (not tapered) poles, one will need improved adhesion or grip designs to help ensure that banded attachments maintain their attachment over many years of cyclic day/night all-weather stresses. The problem is how to obtain maximum initial tension without over-stressing the metallic band and straining the metal material into its inelastic zone where slow relaxation and creep behavior will lead to a premature failure of the band. There are a variety of options for poles that are tapered and/or have polygonic cross-sections with 6, 8, or 12 sides. Saddle brackets and flat-faced hardware can be used to achieve effective, strong and reliable bonds to the pole, particularly if the pole is both tapered and has polygonic cross-section.

With the wide diurnal and seasonal temperature swings expected for climates across the country, the repeated day/night cycles can induce significant differential expansion and contraction behavior between poles and hardware, as well as between different metal components of the hardware. The interdependencies between pole material, pole shape, band hardware shape, design, and materials requires that any candidate banded hardware needs to be adequately tested for:

- Adequate bond strengths
- Ability to work with attachment and pole material
- Drillability – Hardness of material, ductility versus brittle fracture of

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pole material and its response to drilling stress

- Ease-of-Use – A hardware assembly should be easily installed on the pole with appropriate tools and torque forces
- Long-term stability of adhesions and bond
- Effective pole hardware interactions and compatibility
- Long-term stress relaxation – The ability of an attachment to distribute and disperse any torsional and flexural stresses (torque forces)
- Creep or fatigue – Slippage of hardware down poles or metal fatigue of bracket.

The testing of hardware to GR-3174 provides test criteria and procedures to evaluate these failure mechanisms. Furthermore, the product test regimes available for pole-mounted cabinets to GR-487 or for pole-mounted splice closures to either GR-950-CORE, *Telcordia Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems*, or GR-771-CORE, *Generic Requirements for Optical Fiber Splice Closures*, should include earthquake resistance and environmental vibration tests. By the nature of the test procedures, the attachment hardware is evaluated at the same time as the cabinet or splice box.

## 5.16 Normative and Informative References Related to Pole Hardware

1. GR-60-CORE, *Generic Requirements for Wooden Utility Poles*.
2. GR-487-CORE, *Telcordia Generic Requirements for Electronic Equipment Cabinets*.
3. GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*.
4. GR-3159-CORE, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles*.
5. ANSI 05.1, *American National Standard for Wood Poles – Specifications and Dimensions*.
6. ANSI 05.3, *American National Standard for Wood Products – Solid Sawn- Wood Crossarms and Braces – Specifications and Dimensions*.
7. ANSI C136.20, *American National Standard for Roadway Lighting Equipment*  
– *Fiber-Reinforced Plastic (FRP) Lighting Poles*, National Electrical Manufacturers Association.
8. ASCE-48 (ASCE/SEI), *Design of Steel Transmission Pole Structures*.
9. ASCE-74, *Guidelines for Electrical Transmission Line Structural*

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*Loading.*

10. ASCE-104, *Recommended Practice for Fiber-Reinforced Composite Products for Overhead Utility Line Structures*.
11. ASCE-111, *Structural Reliability-Based Design of Utility Poles*, 2006.
12. ASTM A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*.
13. ASTM B117, *Corrosion Resistance Testing Using a Salt Fog Chamber*.
14. ASTM D1036, *Standard Test Methods for Static Tests of Wood Poles*.
15. ASTM D4476, *Standard Test Method for Flexural Properties of Fiber Reinforced Pultruded Plastic Rods*.
16. IEEE P751/D2, *IEEE Design Guide for Wood Transmission Structures*, IEEE Power Engineering Society, 1999.
17. NEMA TT1, *Tapered Tubular Steel Structures*.
18. TIA/EIA-222, *Structural Standards for Antenna Supporting Structures*.
19. TIA/EIA-222-F, *Structural Standards for Steel Antenna Towers and Antenna Supporting Structures*.



## 6 Guying

### 6.1 General

This section defines and illustrates the various types of guys to support poles. It also covers methods of determining guying requirements that apply to all strand-supported cable, including self-supporting cable.

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**! CAUTION !** *All required guying must be in place before placing and tensioning supporting strand.*

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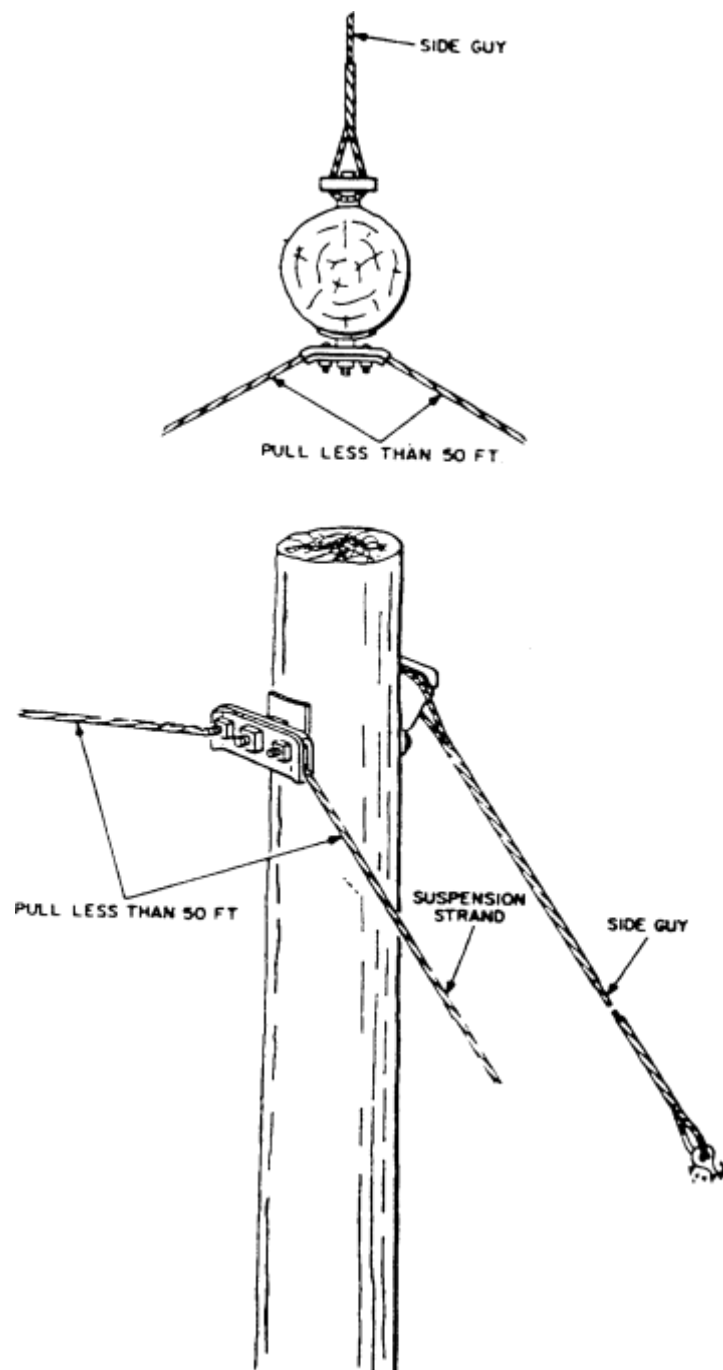
In determining the requirements for guying at angular changes in the direction of a pole line, experience has shown that it is more convenient to measure the angle in “feet (meters) of pull” than in degrees. Knowing the “feet (meters) of pull” at a corner pole is necessary if the correct guy size is to be determined. A tool, the pull finder, is available for use in determining the amount of pull, and its description and use are covered in this chapter.

### 6.2 Types of Guys

The following are definitions of the type of guys:

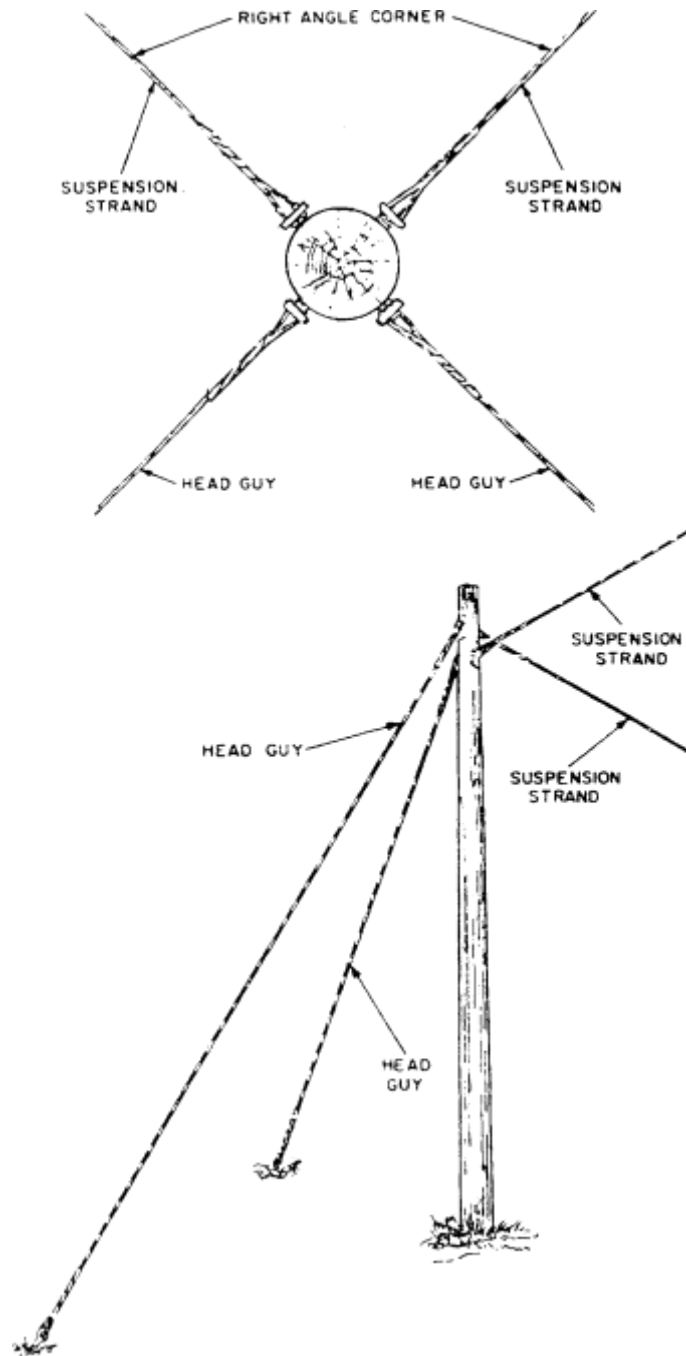
- **Side Guy** – A guy placed in a transverse direction to the line of the lead ([Figure 6-1](#)).
- **Head Guy** – A guy placed in the line with the lead ([Figure 6-2](#)).
- **Anchor Guy** – A guy extending from a pole or guy stub to an anchorage in the ground ([Figure 6-3](#)).
- **Pole-to-Stub Guy** – A guy strand run between a pole in the main lead and a stub pole ([Figure 6-3](#)).
- **Pole-to-Pole Guy** – A guy strand run between two poles in the lead ([Figure 6-4](#)).
- **Sidewalk Anchor Guy** – A guy that is used over a sidewalk or other pathway where right-of-way conditions do not permit placing an anchor guy with sufficient lead to provide the required clearance above the sidewalk ([Figure 6-5](#)).

**Note:** Based on a mechanical analysis of the breaking strength of the strands and the buckling strength of the pipe, the galvanized iron pipe used should be Schedule 80 pipe for the sidewalk anchor guy configuration. Schedule 40 galvanized pipe will be adequate for most situations, but Schedule 80 or thicker pipes are preferred.

**Figure 6-1 Side Guy**

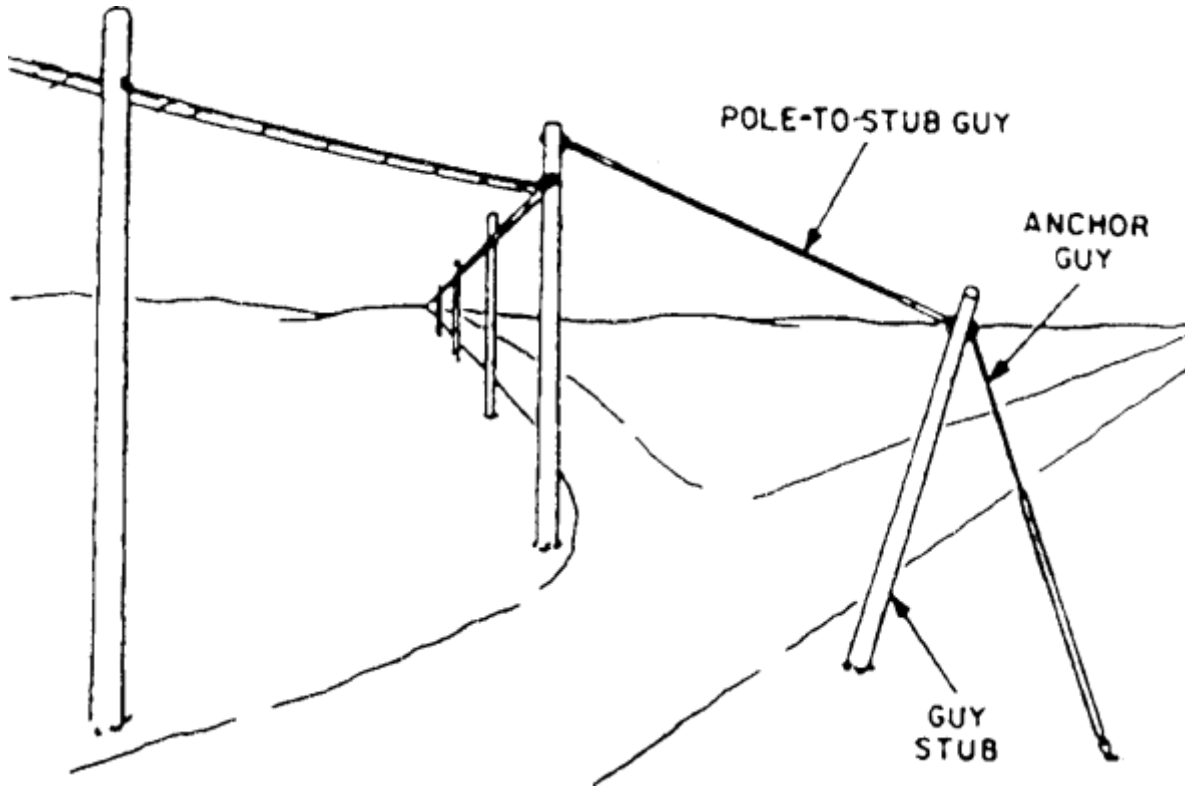
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**Figure 6-2 Side Guy**

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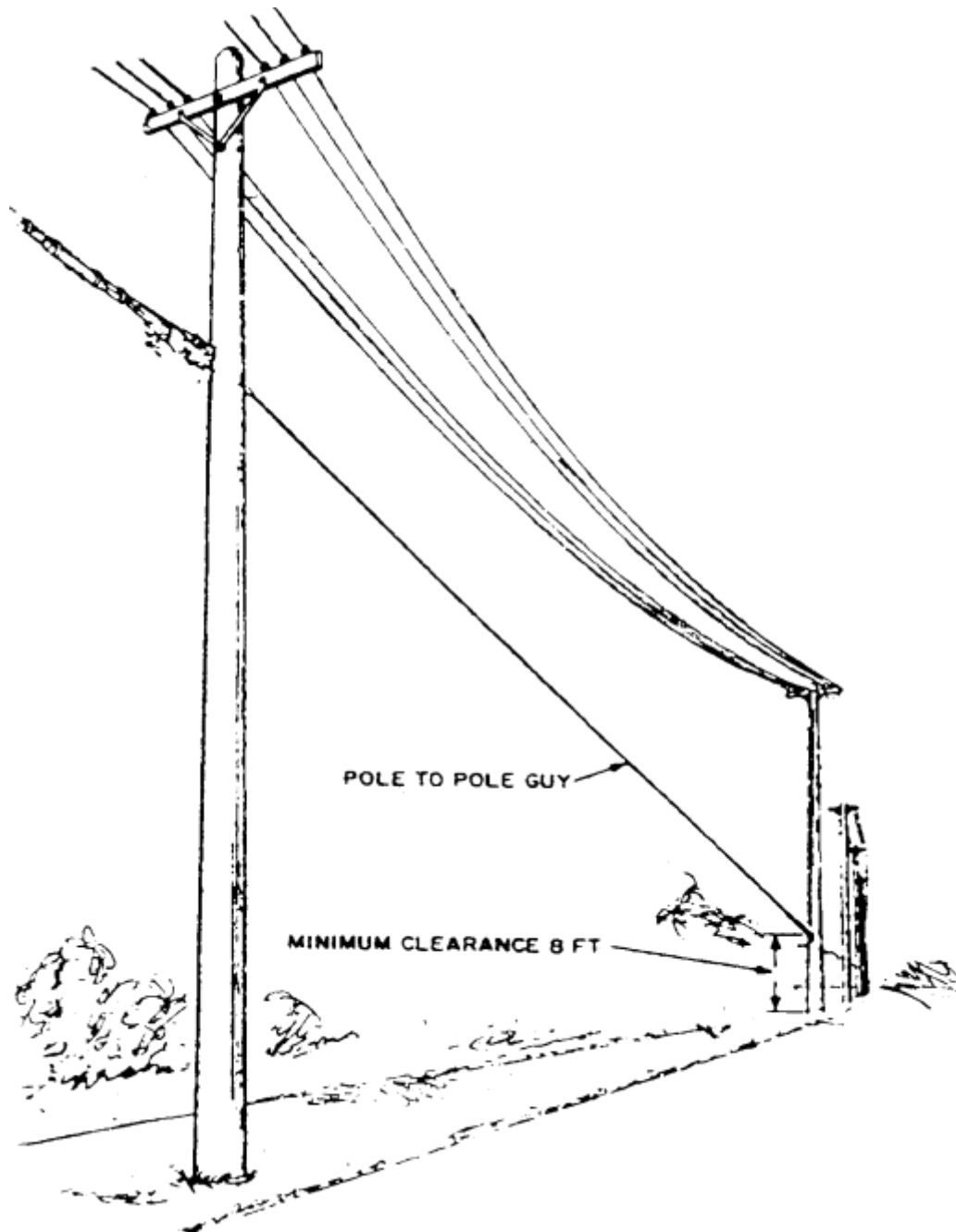
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**Figure 6-3 Pole-to-Stub Guy**

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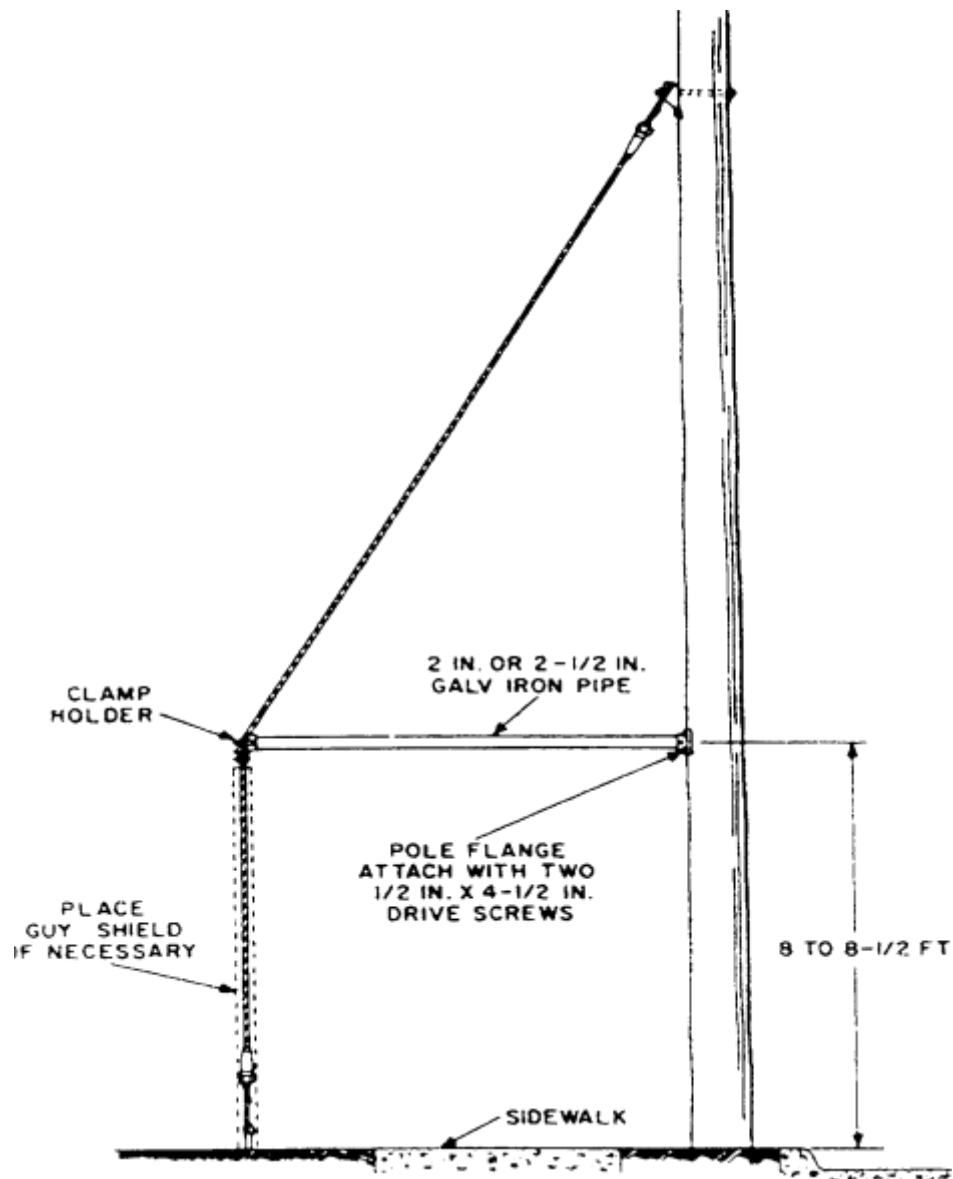
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**Figure 6-4 Pole-to-Pole Guy**

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**Figure 6-5 Sidewalk Anchor Guy**

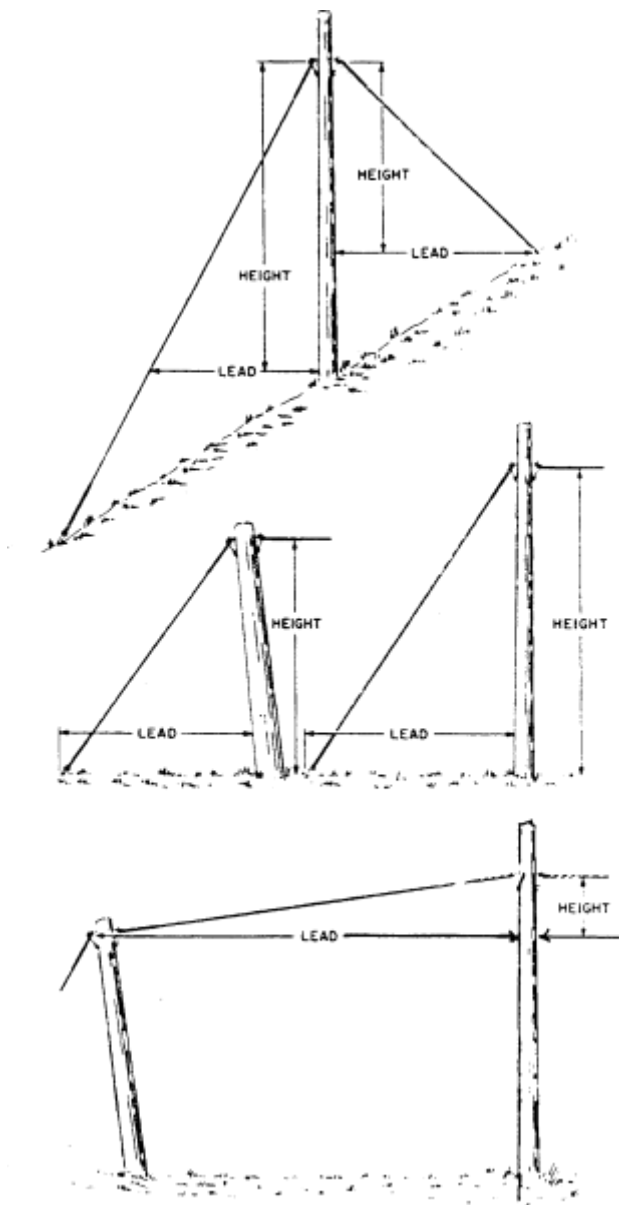
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### 6.3 Determining Lead and Height

The lead and height of a guy is defined as distances in feet (meters), measured as shown in [Figure 6-6](#), and expressed as a fraction to give the lead-over-height ratio. For example, a lead of 15 feet and a height of 30 feet can be expressed as 15/30 feet, or as a lead-over-height ratio of 1/2.

**Figure 6-6 Lead and Height Measurements**

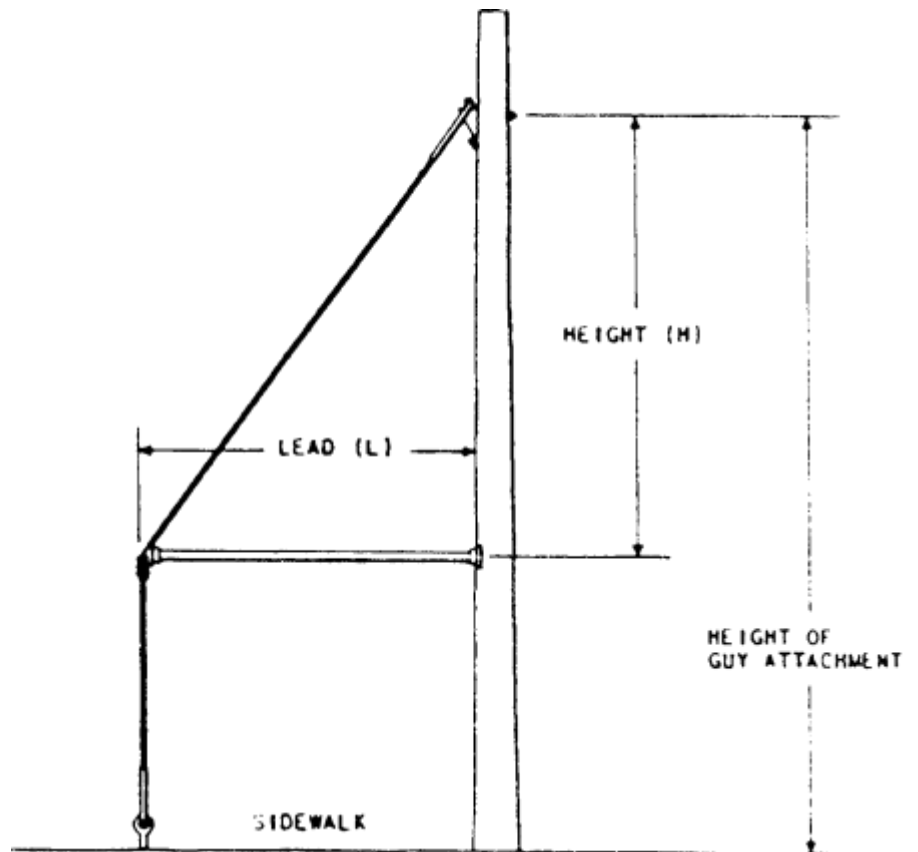


For determining the lead and height of a sidewalk anchor guy, refer to [Figure 6-7](#).

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**Figure 6-7 Lead and Height Measurements for Sidewalk Anchor Guy**

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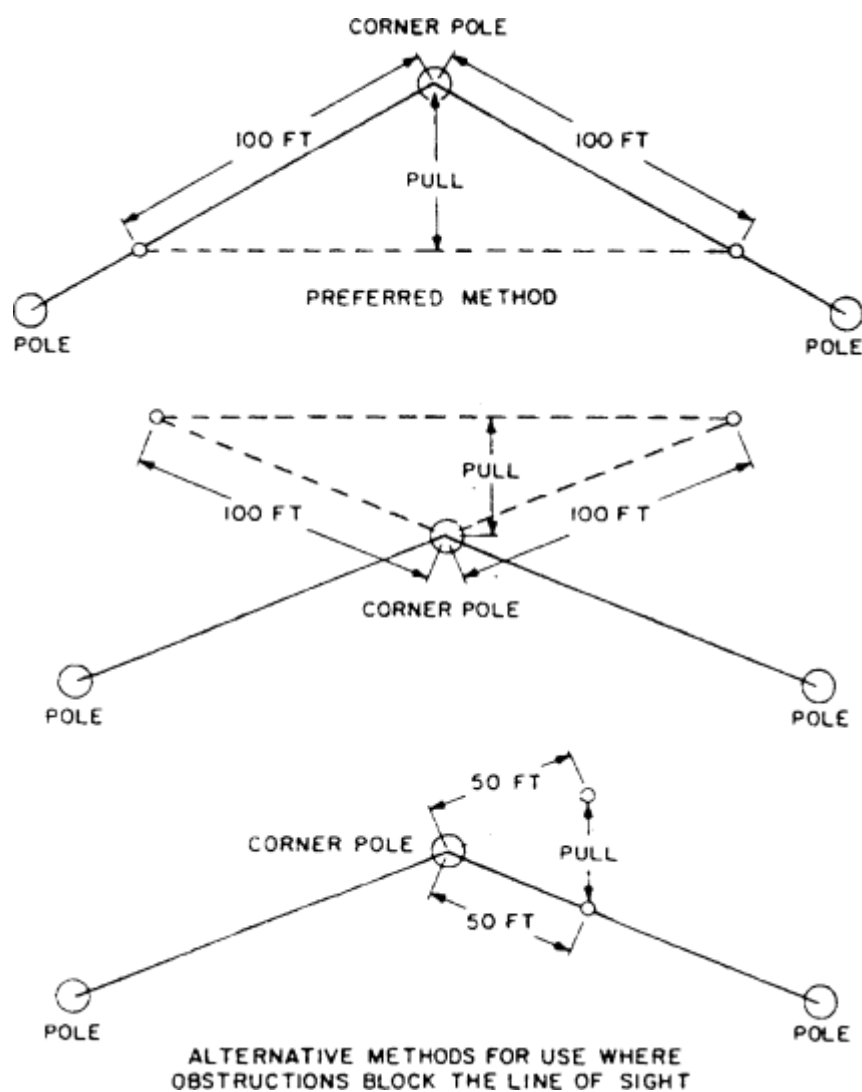


## 6.4 Determining Pull

Pull at a corner pole may be determined by measuring the distance in feet from the pole to a point away from the pole, as shown in [Figure 6-8](#). The preferred and alternative methods are shown in the figure.

The pull at a corner pole can more conveniently be ascertained by using a pull finder, as described in [Section 6.5](#) and [Section 6.6](#).

**Figure 6-8 Measuring Corner Pull (Taping)**



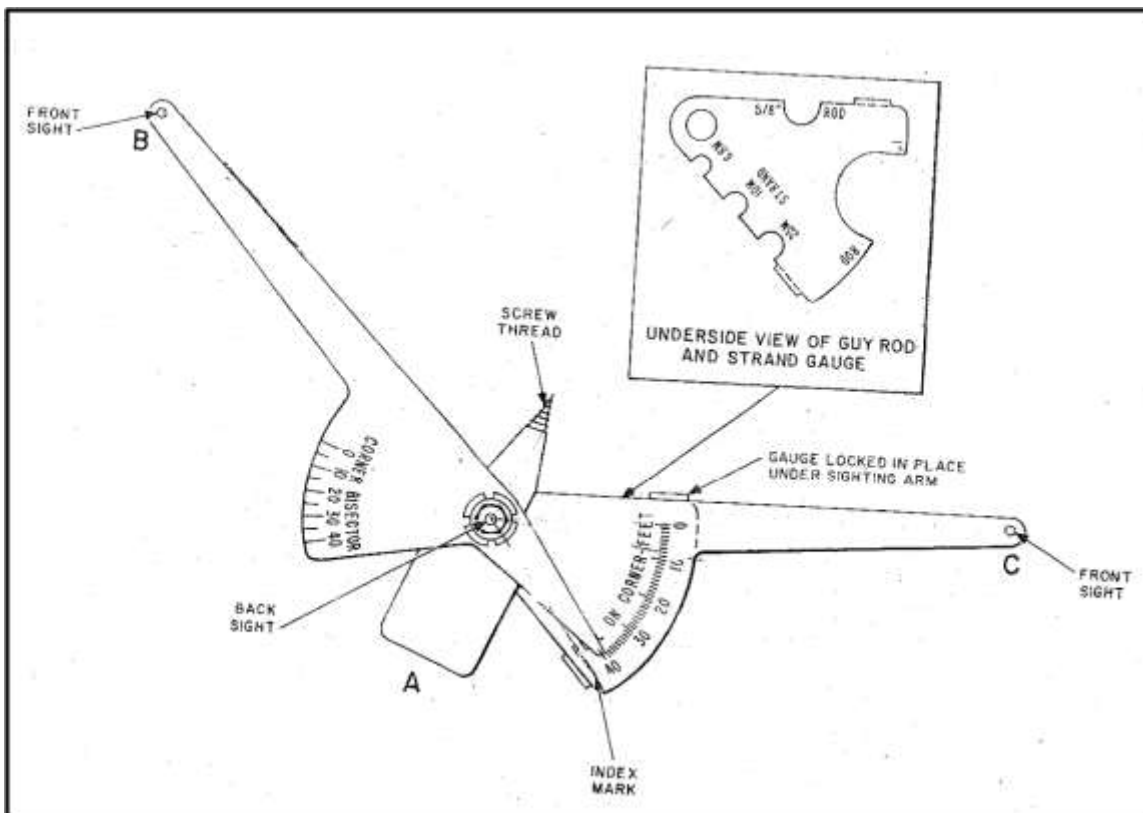
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## 6.5 Pull Finder Description

A pull finder, as shown in Figure 6-9, consists of two pivoting sighting arms and a short arm that supports the sighting arms. The short arm has a threaded point that screws into a pole and supports the tools. The pull finder illustrated has an integral guy rod and strand gauge, but other

Figure 6-9 Pull Finder



models may not.

The pointer on Arm B indicates the pull in feet on the scale inscribed on Arm C. The other scale inscribed on Arm B, when used with the index mark of Arm C, enables Arm C to be swung around and pointed along the correct bisecting line of the corner angle. Front sight pins, located at the end of each sighting arm, are used for alignment with a pin or back sight on top of the pivot bolt assembly.

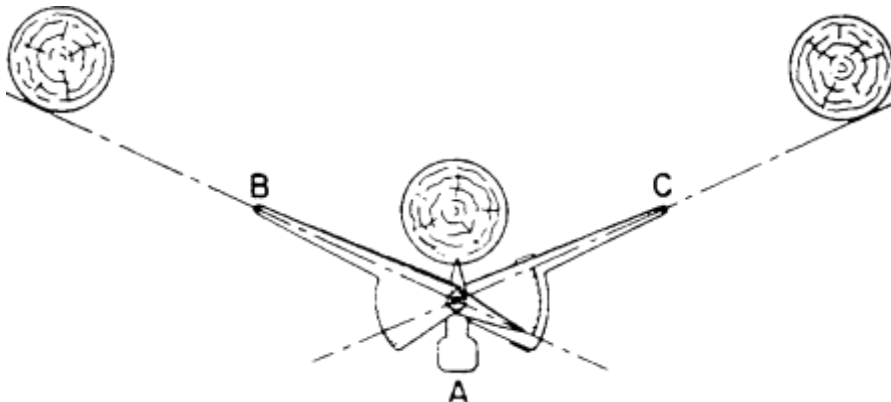
## 6.6 Pull Finder Use

### 6.6.1 To Measure Pull

To determine the pull at a corner pole using the pull finder, follow these steps:

1. Screw the short Arm A into the corner pole as shown in [Figure 6-10](#).
2. Adjust Arm C so the line of sight, when sighting over the back sight and the front sight on Arm C, is tangent to the surface of the pole adjacent to the corner pole.
3. Similarly, line up Arm B by sighting on the other pole adjacent to the corner pole.
4. Check Arm C to make certain it has not moved.
5. The pointer on Arm B now indicates on the scale on Arm C, the pull in feet at the corner.

**Figure 6-10 Determining the Corner Pull With a Pull Finder**



### 6.6.2 To Bisect the Angle

The pull finder, in addition to being used to determine the pull at a corner pole, can be used to quickly and conveniently bisect the angle of the corner pull for locating the anchor or stub pole. To bisect the angle, proceed as follows:

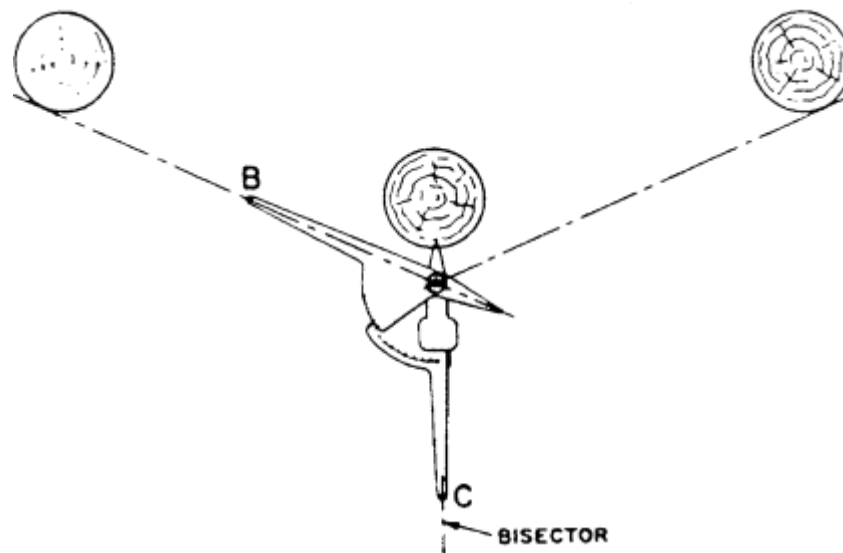
1. Mount the pull finder on the corner pole and measure the pull in feet, as described in [Section 6.6.1](#).
2. Without disturbing Arm B, swing Arm C away from the pole until the

index mark (located just beyond the 40-foot mark on the pull scale) points to the pull reading (determined in Step 1 above) as read on the Corner Bisector scale on Arm B.

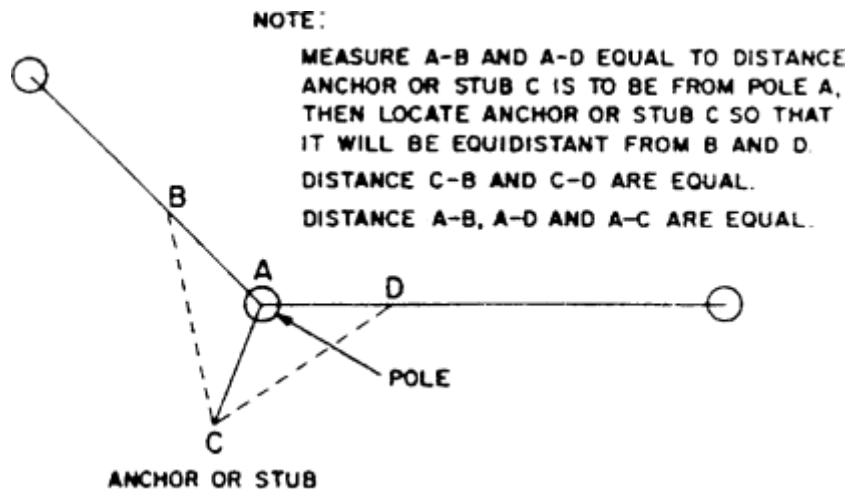
3. Arm C is now in line with the bisector of the corner angle (Figure 6-11), and the anchor or guy stub should be located in line with the back sight and the front sight on Arm C.

If the anchor or guy stub location is so far away that the sights on the pull finder cannot be observed accurately, place a digging bar or a range rod on the bisector line a few feet away from the pole where the pole finder sights may then be located in line with this marker and the corner pole.

**Figure 6-11 Bisecting Corner Pull With Pull Finder**



When a pull finder is not available or cannot be used because of an obstruction, bisecting the angle of pull can be accomplished as shown in Figure 6-12.

**Figure 6-12 Bisecting Angle by Tape Measurement**

## 6.7 Determining Guy Strand Size

After the pull at the pole and lead-over-height ratio have been determined and the size of the suspension strand or strands is known, the proper size strand for guys can be determined by using the tables in this section or a circular Guy Rule. [Table 6-1](#) provides the size of strand required for head guys, and [Table 6-2](#) to [Table 6-5](#) give the strand sizes for side guys. Refer to [Chapter 4](#) ([Table 4-1](#)) for strand breaking strength in pounds and diameters of strands. Refer to [Section 6.1](#) through [Section 6.6](#) for the definitions and measurement procedures for the characteristics of lead/height ratio, pull on poles, and other related parameters.

Table 6-1 Head Guy Strand Sizes

| Suspension Strand Size (Inch)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Lead-Over-Height Ratio (Note 1)                                |      |      |      |      |      |      |      |      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|------|------|------|------|------|------|------|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1/5                                                            | 1/4  | 3/10 | 1/3  | 2/5  | 1/2  | 3/5  | 2/3  | 3/4  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Size of Guy Strand(s) Required [Equivalent M Value - Note (2)] |      |      |      |      |      |      |      |      |
| 6.6 M (1/4")                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 32 M                                                           | 25 M | 22 M | 20 M | 20 M | 16 M | 12 M | 12 M | 10 M |
| 6 M (5/16")                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 32 M                                                           | 25 M | 22 M | 20 M | 20 M | 16 M | 12 M | 12 M | 10 M |
| 10 M (3/8")                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 60 M                                                           | 42 M | 36 M | 32 M | 30 M | 25 M | 20 M | 20 M | 20 M |
| 16 M (5/8")                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 90 M                                                           | 70 M | 60 M | 60 M | 48 M | 42 M | 32 M | 30 M | 30 M |
| <p><b>Note 1:</b> Lead-over-height ratio (see <a href="#">Figure 6-6</a>) - A ratio of 2/5 equates to a guy dropping 25 feet in height over a distance (lead) of 10 feet = 10 feet lead/25 feet height = 10/25 ratio = 2/5 ratio.</p> <p><b>Note 2:</b> To obtain a head guy with sufficient strength, it is assumed that multiple guy strands will be combined to attain the required strength. For example, to provide a 32 M head guy, one would use two 16 M (5/8 inch) guys on the pole. See <a href="#">Table 4-1</a> for the full range of typical strand sizes and breaking strength cross reference.</p> |                                                                |      |      |      |      |      |      |      |      |

Table 6-2 Side Guy Strand Sizes for 6.6 M Suspension Strand

| Pull On Pole Feet | Lead-Over-Height Ratio                           |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
|-------------------|--------------------------------------------------|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-----|-----|
|                   | 1/5                                              | 1/4 | 3/10 | 1/3 | 2/5 | 1/2 | 3/5 | 2/3 | 3/4 | 4/5 | 1/1 | 1-1/4 | 1-1/2 | 2   | 4   |
|                   | Size of Guy Strand Required (Equivalent M Value) |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
| 4                 | 6                                                | 2.2 | 2.2  | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 10                | 10                                               | 6   | 6    | 6   | 6   | 6   | 6   | 6   | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 15                | 12                                               | 10  | 10   | 10  | 6   | 6   | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 2.2 | 2.2 |
| 20                | 16                                               | 12  | 10   | 10  | 10  | 10  | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 25                | 20                                               | 16  | 12   | 12  | 10  | 10  | 10  | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 30                | 22                                               | 18  | 16   | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 6   | 6     | 6     | 6   | 6   |
| 35                | 26                                               | 20  | 18   | 16  | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 6     | 6     | 6   | 6   |
| 40                | 30                                               | 22  | 20   | 20  | 16  | 12  | 12  | 10  | 10  | 10  | 10  | 10    | 10    | 6   | 6   |
| 45                | 32                                               | 26  | 22   | 20  | 20  | 16  | 12  | 12  | 10  | 10  | 10  | 10    | 10    | 10  | 6   |

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Table 6-3 Side Guy Strand Sizes for 6 M Suspension Strand

| Pull On Pole Feet | Lead-Over-Height Ratio                           |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
|-------------------|--------------------------------------------------|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-----|-----|
|                   | 1/5                                              | 1/4 | 3/10 | 1/3 | 2/5 | 1/2 | 3/5 | 2/3 | 3/4 | 4/5 | 1/1 | 1-1/4 | 1-1/2 | 2   | 4   |
|                   | Size of Guy Strand Required (Equivalent M Value) |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
| 4                 | 6                                                | 2.2 | 2.2  | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 10                | 10                                               | 6   | 6    | 6   | 6   | 6   | 6   | 2.2 | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 15                | 10                                               | 10  | 10   | 6   | 6   | 6   | 6   | 6   | 6   | 6   | 6   | 6     | 2.2   | 2.2 | 2.2 |
| 20                | 16                                               | 10  | 10   | 10  | 10  | 6   | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 25                | 16                                               | 16  | 12   | 10  | 10  | 10  | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 30                | 20                                               | 16  | 16   | 12  | 10  | 10  | 10  | 10  | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 35                | 22                                               | 20  | 16   | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 6   | 6     | 6     | 6   | 6   |
| 40                | 26                                               | 20  | 20   | 16  | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 10    | 6     | 6   | 6   |
| 45                | 30                                               | 20  | 20   | 20  | 16  | 12  | 12  | 10  | 10  | 10  | 10  | 10    | 10    | 6   | 6   |

Table 6-4 Side Guy Strand Sizes for 10 M Suspension Strand

| Pull On Pole Feet | Lead-Over-Height Ratio                           |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
|-------------------|--------------------------------------------------|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-----|-----|
|                   | 1/5                                              | 1/4 | 3/10 | 1/3 | 2/5 | 1/2 | 3/5 | 2/3 | 3/4 | 4/5 | 1/1 | 1-1/4 | 1-1/2 | 2   | 4   |
|                   | Size of Guy Strand Required (Equivalent M Value) |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
| 4                 | 6                                                | 6   | 6    | 6   | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 10                | 12                                               | 10  | 10   | 10  | 6   | 6   | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 2.2 | 2.2 |
| 15                | 16                                               | 16  | 12   | 10  | 10  | 10  | 6   | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 20                | 20                                               | 20  | 16   | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 6   | 6     | 6     | 6   | 6   |
| 25                | 26                                               | 22  | 20   | 18  | 16  | 12  | 12  | 10  | 10  | 10  | 10  | 10    | 10    | 6   | 6   |
| 30                | 32                                               | 26  | 22   | 20  | 20  | 16  | 12  | 12  | 10  | 10  | 10  | 10    | 10    | 10  | 10  |
| 35                | 40                                               | 30  | 26   | 26  | 20  | 18  | 16  | 16  | 12  | 12  | 12  | 10    | 10    | 10  | 10  |
| 40                | 42                                               | 36  | 30   | 26  | 22  | 20  | 16  | 16  | 16  | 16  | 12  | 12    | 10    | 10  | 10  |
| 45                | 48                                               | 42  | 32   | 30  | 26  | 22  | 20  | 20  | 16  | 16  | 16  | 12    | 12    | 10  | 10  |

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Table 6-5 Side Guy Strand Sizes for 16 M Suspension Strand

| Pull On Pole in Feet | Lead-Over-Height Ratio                           |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
|----------------------|--------------------------------------------------|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-----|-----|
|                      | 1/5                                              | 1/4 | 3/10 | 1/3 | 2/5 | 1/2 | 3/5 | 2/3 | 3/4 | 4/5 | 1/1 | 1-1/4 | 1-1/2 | 2   | 4   |
|                      | Size of Guy Strand Required (Equivalent M Value) |     |      |     |     |     |     |     |     |     |     |       |       |     |     |
| 4                    | 10                                               | 6   | 6    | 6   | 6   | 6   | 6   | 6   | 2.2 | 2.2 | 2.2 | 2.2   | 2.2   | 2.2 | 2.2 |
| 10                   | 18                                               | 16  | 12   | 12  | 10  | 10  | 10  | 6   | 6   | 6   | 6   | 6     | 6     | 6   | 6   |
| 15                   | 26                                               | 22  | 20   | 16  | 16  | 12  | 10  | 10  | 10  | 10  | 10  | 10    | 6     | 6   | 6   |
| 20                   | 36                                               | 30  | 22   | 22  | 20  | 16  | 16  | 12  | 12  | 12  | 10  | 10    | 10    | 10  | 10  |
| 25                   | 42                                               | 36  | 30   | 28  | 22  | 20  | 16  | 16  | 16  | 16  | 12  | 12    | 10    | 10  | 10  |
| 30                   | 60                                               | 42  | 36   | 32  | 30  | 22  | 20  | 20  | 18  | 16  | 16  | 16    | 12    | 12  | 10  |
| 35                   | 60                                               | 48  | 42   | 40  | 32  | 26  | 22  | 22  | 20  | 20  | 18  | 16    | 16    | 16  | 12  |
| 40                   | 70                                               | 60  | 48   | 42  | 36  | 30  | 26  | 26  | 22  | 22  | 20  | 20    | 16    | 16  | 16  |
| 45                   | 80                                               | 60  | 60   | 48  | 42  | 32  | 30  | 26  | 26  | 26  | 22  | 20    | 20    | 20  | 16  |

If guy lines support more than one suspension strand, except if two strands are supported on the same suspension bolt, it is preferable to guy each strand separately. This is especially true for head guys.

Where it is not practical to guy each suspension strand separately, exceptions may be made as follows:

- A. *For head guys or side guys*, a single guy may be used where the separation between suspension strands is 2 feet or less. The single guy strand must be of adequate size to withstand the combined load. For example: Assume that a 6.6 M suspension strand and a 6 M suspension strand are on the same pole and there is a 15-foot pull at the pole. If separate guys were used, one would be a 6.6 M strand and the other would be a 6 M strand. If one guy is used, it must be a 10 M strand.
- B. *At corners with a pull of 6 feet or less*, a single guy may be used for three 16 M or smaller suspension strands.

The size of the strand required for a sidewalk anchor guy is greater than that required for an anchor guy of the usual type having the same lead-over-height ratio. To determine the size of the strand for the sidewalk anchor guy, first determine the size of the anchor guy that would be required if the usual type having the same lead and height were to be placed (refer to the above tables and discussion in



[Section 6.7](#)). The size of the strand for the sidewalk anchor guy should then be selected in accordance with [Table 6-6](#).

**Table 6-6 Guy Strand Sizes for Sidewalk Anchor Guys**

| Height of Guy Attachment in Feet | Size of Guy as Determined from <a href="#">Table 6-1</a> to <a href="#">Table 6-5</a> |       |      |      |      |
|----------------------------------|---------------------------------------------------------------------------------------|-------|------|------|------|
|                                  | 2.2 M                                                                                 | 6.6 M | 6 M  | 10 M | 16 M |
|                                  | Size of Strand (M) for Sidewalk Anchor Guy [Note 1]                                   |       |      |      |      |
| 26                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 25                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 24                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 23                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 22                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 21                               | 6 M                                                                                   | 10 M  | 10 M | 16 M | 25 M |
| 20                               | 6 M                                                                                   | 10 M  | 10 M | 20 M | 25 M |
| 19                               | 6 M                                                                                   | 10 M  | 10 M | 20 M | 25 M |
| 18                               | 6 M                                                                                   | 10 M  | 10 M | 20 M | 25 M |

**Note 1:** Where a 25 M guy strand is required, a combination of one 16 M strand and one 10 M strand would normally be used. If a 20 M guy is called for, use two 10 M strands or one 16 M plus one 6 M strand. When two guy strands are to be attached to the same fixture at different levels, use the height of attachment of the lower guy to determine the size of strand for the guys.

### 6.7.1 Dead-End Poles

Head guys should be used at all dead-end poles and at corner poles where the pull is more than 50 feet.

The size of the strand used for head guys can be the same as the suspension strand if the lead-over-height ratio is  $\frac{3}{4}$  or greater. When the lead-over-height ratio is less than  $\frac{3}{4}$ , use [Table 6-1](#) to determine the size of the guy strand.

The following figures illustrate how head guys should be installed at strand dead-ends.

- Where a single guy is used for one suspension strand, place the guy as

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shown in Figure 6-13.

- Where a single guy is used for two suspension strands with a separation of 2 feet or less, place the guy as shown in Figure 6-14.
- Where there is one suspension strand and two guys are required, place guys as shown in Figure 6-15.
- Where three guys are required with two suspension strands, place guys as shown in Figure 6-16.

**Figure 6-13 One Head Guy for One Suspension Strand**

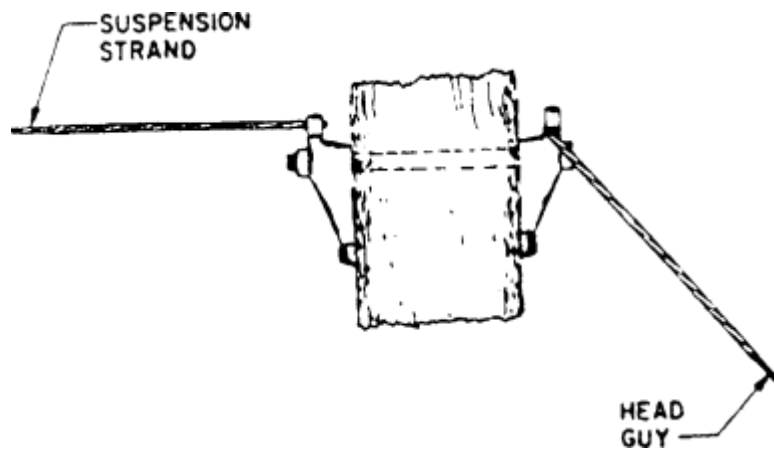
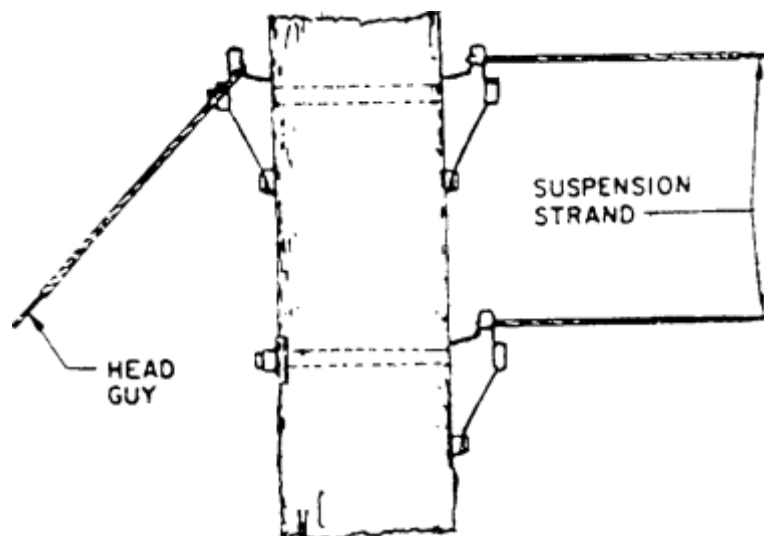
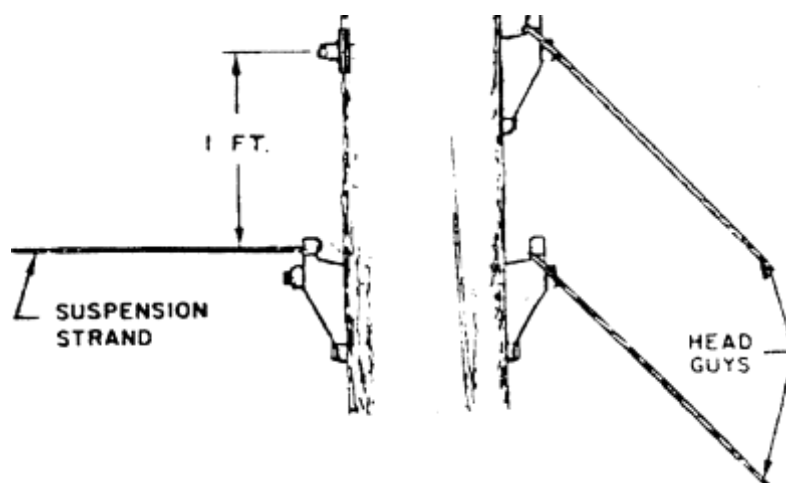
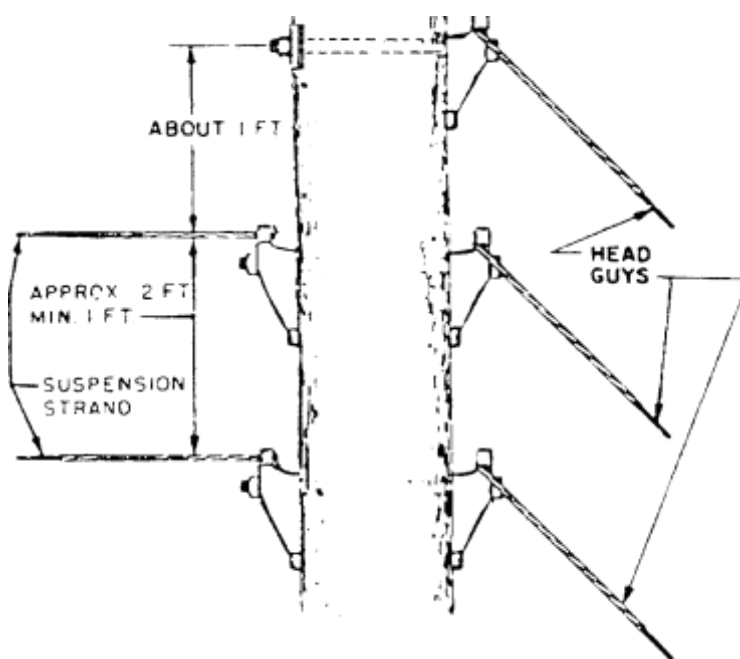


**Figure 6-14 One Head Guy for Two Suspension Strands**



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**Figure 6-15 Two Head Guys for One Suspension Strand****Figure 6-16 Three Head Guys for Two Suspension Strands**

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### 6.7.2 Corner Poles

Corner poles shall be guyed where the pull is:

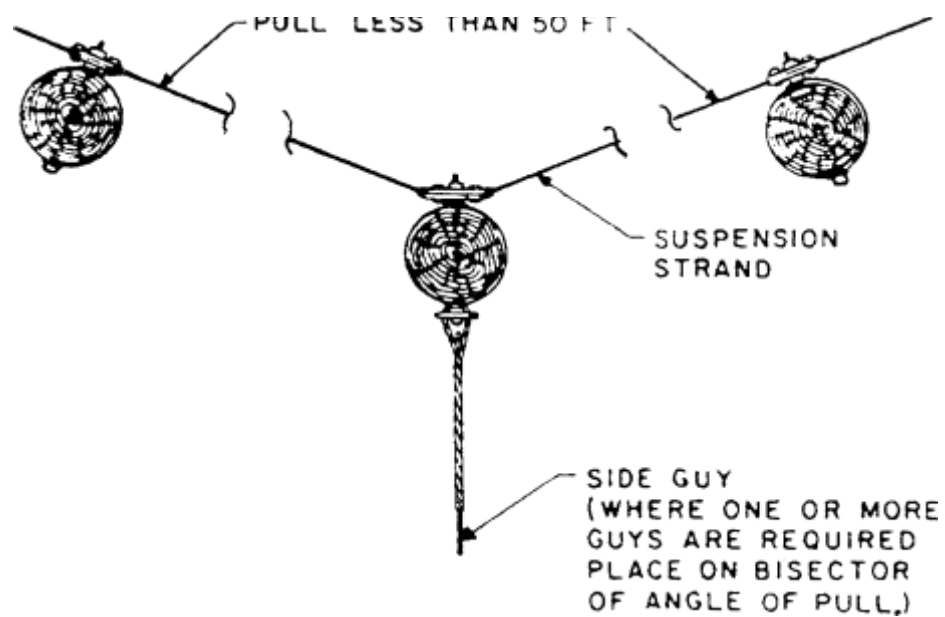
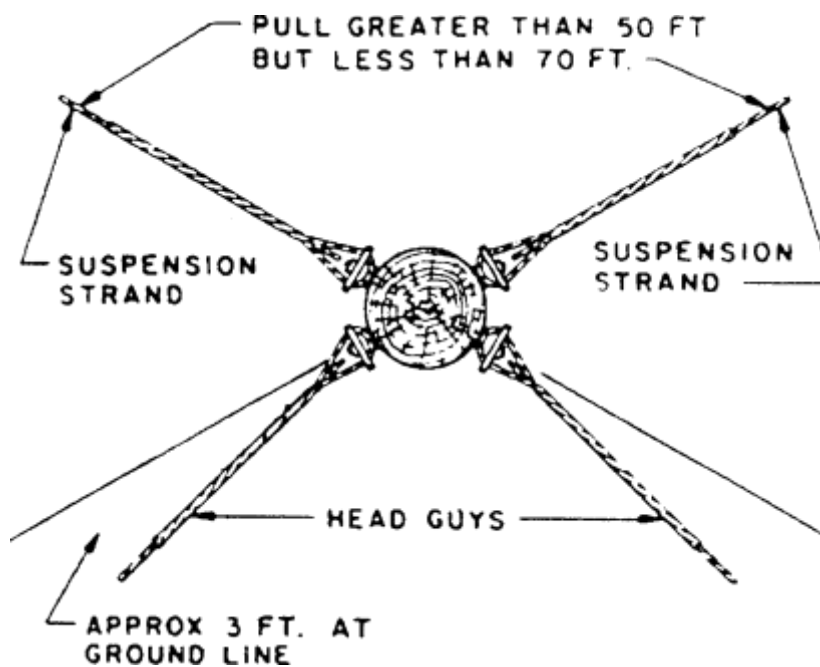
- 4 feet or more, and a 6.6 M suspension strand is in place
- 3 feet or more, and a 6 M suspension strand is in place
- 2 feet or more, and a 10 M suspension strand is in place
- 1 foot or more, and a 16 M suspension strand is in place.

Sometimes if many cables or strands are present on a pole, it may require a guy, even though the corner is within the above parameters.

Side guys can be installed on all poles where the pull is less than 50 feet. [Table 6-2](#) and [Table 6-3](#) show the sizes of guy strand for various leads and corner pulls, based on the size of the suspension strand.

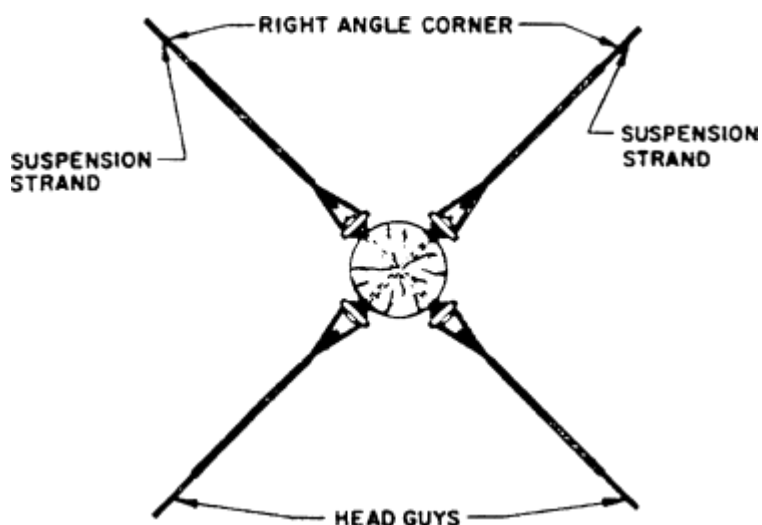
[Figure 6-17](#) through [Figure 6-19](#) illustrate the guy arrangements for various corner pull situations.

- Where the pull on the corner pole is 50 feet or less, place a side guy bisecting the corner angle (see [Figure 6-17](#)).
- Where the pull on the corner pole exceeds 50 feet, but is less than a right angle, place two head guys as shown in [Figure 6-18](#).
- At right-angle corners (70-foot pull) made on one pole, two head guys shall be placed as shown in [Figure 6-19](#). Each guy shall be in line with the suspension strand that it supports.

**Figure 6-18 Corner Pole With Guys on Bisector of Angle of Pull****Figure 6-17 Corner Pole With Two Head Guys**

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**Figure 6-19 Right-Angle Corner Made on One Pole**

### 6.7.3 Sidewalk Anchor Guys

Select the pipe size for sidewalk anchor guys in accordance with [Table 6-7](#).

**Table 6-7 Pipe Sizes for Sidewalk Anchor Guys**

| Length of Pipe in Feet | Size of Sidewalk Anchor Guy |     |       |       |       |
|------------------------|-----------------------------|-----|-------|-------|-------|
|                        | 6.6 M                       | 6 M | 10 M  | 16 M  | 25 M  |
|                        | Size of Pipe in Inches      |     |       |       |       |
| 6                      | 2                           | 2   | 2     | 2     | 2     |
| 7                      | 2                           | 2   | 2     | 2     | 2     |
| 8                      | 2                           | 2   | 2     | 2     | 2-1/2 |
| 9                      | 2                           | 2   | 2     | 2     | 2-1/2 |
| 10                     | 2                           | 2   | 2     | 2-1/2 | 2-1/2 |
| 11                     | 2                           | 2   | 2     | 2-1/2 | 2-1/2 |
| 12                     | 2                           | 2   | 2-1/2 | 2-1/2 | 2-1/2 |

[Figure 6-20](#) shows the pipe installation details for sidewalk guys.

The anchor should be selected on the basis of the size of the strand required for the sidewalk anchor guy and should be set vertically to a depth 1 foot greater than the vertical depth of the setting normally required.

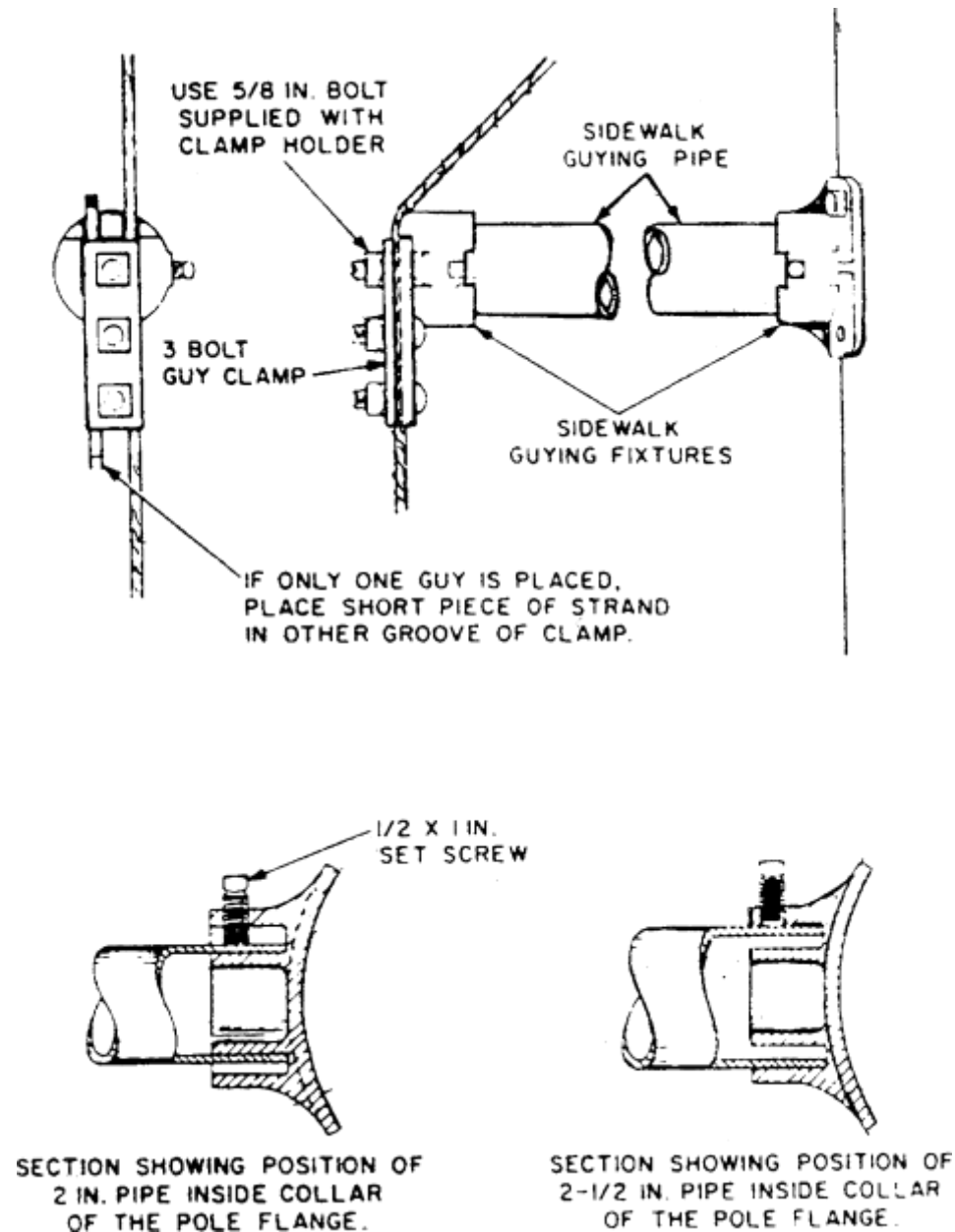
Place the guy shield as shown in [Figure 6-21](#). If a double thimble guy rod and two guys are required, place the guy shield on the guy nearer the sidewalk.

It is essential that poles have adequate residual circumference at the ground line to support the additional stress where sidewalk anchors are to be installed. The residual ground line circumference required is based on the following:

- Existing Load
- Height of the Pole
- Lead-over-Height Ratio
- Size of the Guy Strand
- Height of Attachments.

Because of the variety of these factors, the communications company (i.e., pole owner) must be consulted before installation of the sidewalk guy to determine if the existing pole has adequate strength to support the additional load.

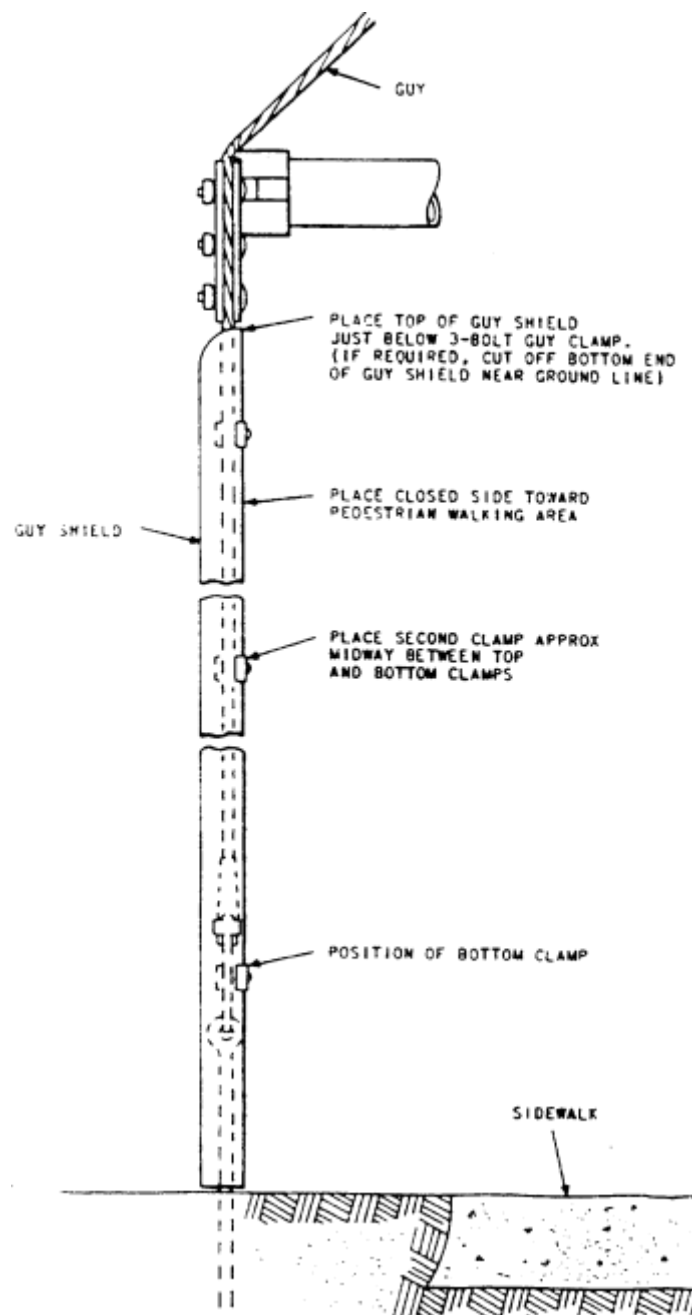
Using larger strands (such as 32M guy strand) for a sidewalk anchor are not advisable since the possibility of exceeding the bending strength of the pipe or the possibility of exceeding the integrity (strength) of the attachment of the pipe to the pole is likely. If such a large guy strand is needed, then it may be safer to set a Pole-to-Stub Guy, where the guy strand is run between a pole in the main lead and a stub pole (Figure 6-3).

**Figure 6-20 Pipe Installation for Sidewalk Anchor Guy**

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**Figure 6-21 Guy Shield Installation for Sidewalk Anchor Guy**

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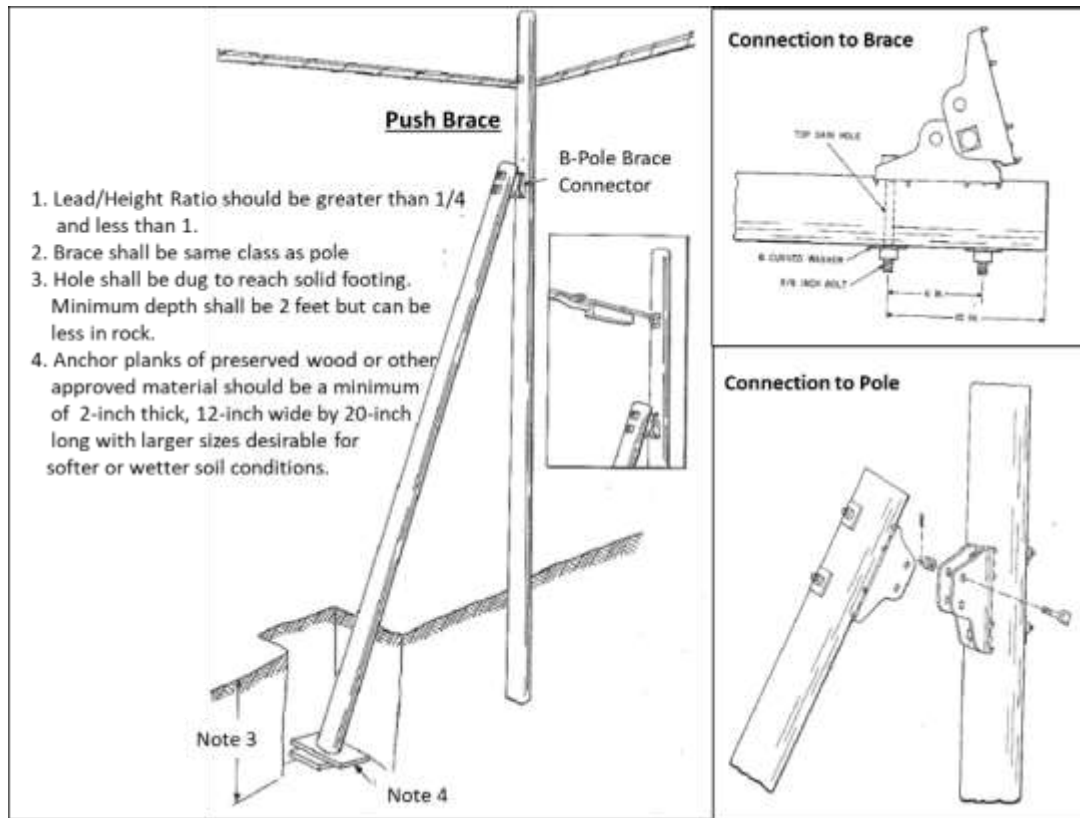
## 6.8 Braces and H-Fixtures

The installation of pole braces and H fixtures are substitutes for side or head guys when safety, economy, and structural advantages favor their use. Typical situations include where Rights-of-Way difficulties, long highway crossings, soil conditions or inadequate clearances make pole braces more desirable than anchor guys.

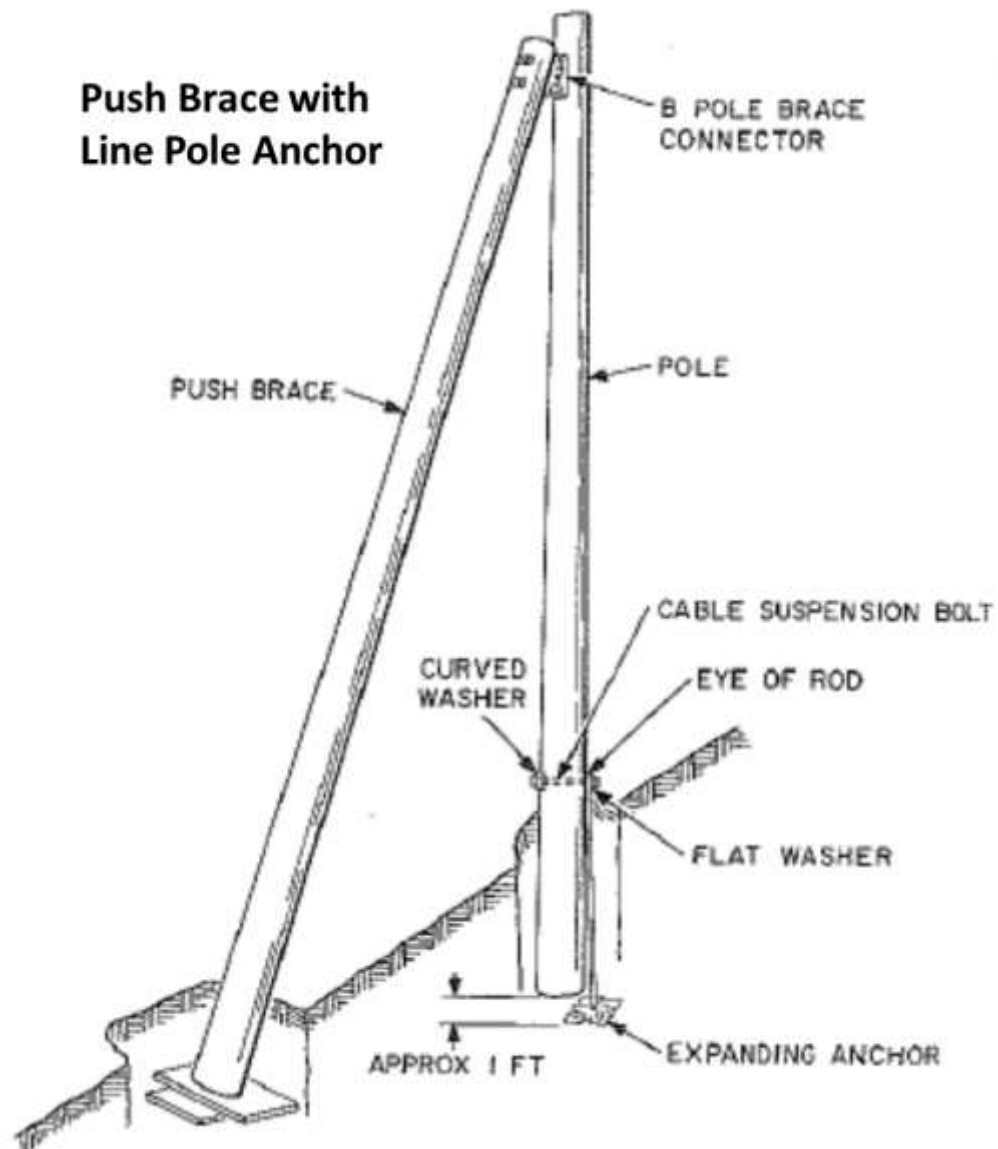
### 6.8.1 Braces

A push brace, as shown in Figure 6-22 can be used in place of a side guy in one direction at a line pole or head guy at a dead-end pole.

**Figure 6-22 Push Brace Configuration**



If a push brace is placed with a Lead/Height ratio of less than  $1/2$  it is desirable to anchor the pole as shown in Figure 6-23 to prevent it from lifting out.

**Figure 6-23 Push Brace with Line Pole Anchor Configuration**

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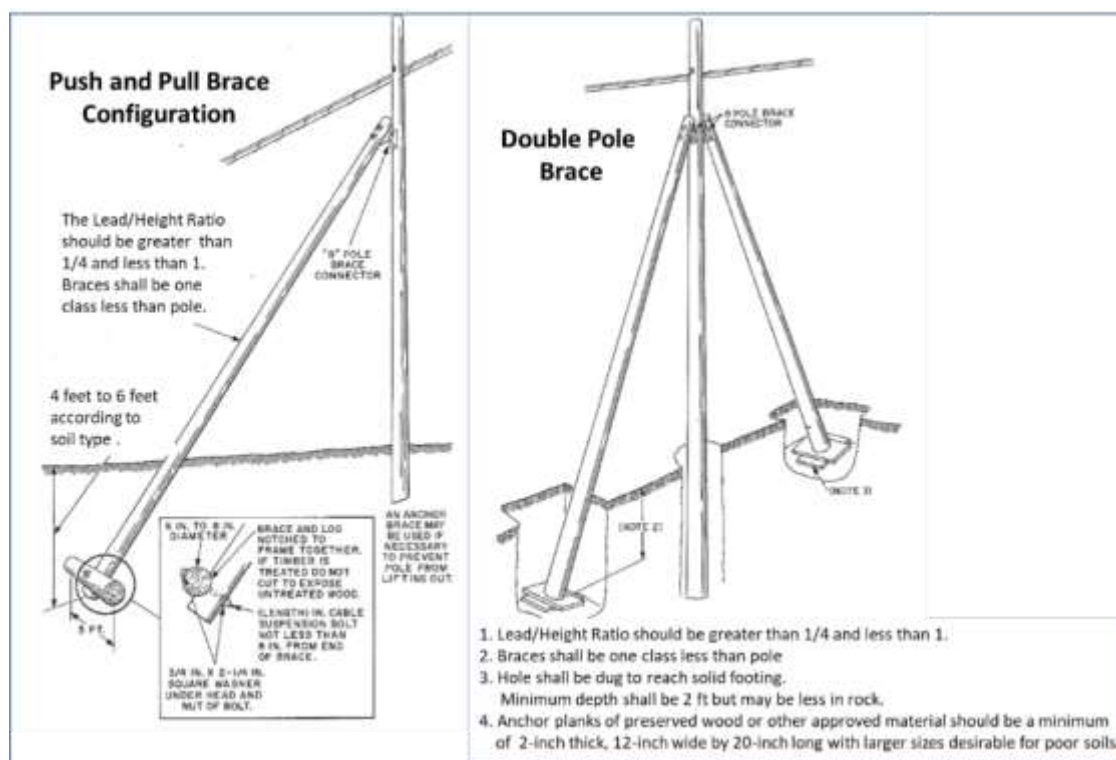
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**Table 6-8 Push Guys Brace and Line Pole Anchor**

| Anchor         |             |          |
|----------------|-------------|----------|
| Depth of Set   | Anchor Size | Rod Size |
| Less than 6 ft | 6           | 1/2 x 7  |
| 6 ft to 7 ft   | 8           | 5/8 x 8  |
| 7.5 ft to 8 ft | 10          | 3/4 x 9  |
| Over 8 ft      | 12          | 1 x 10   |

A combination of a push and a pull brace can be used a substitute for side guys in both directions where (for instance) an installation is in marshy ground if rights-of-way cannot be secured and it is impractical to place an H Fixture.

Other choices for marshy ground could include using a double pole brace to reinforce an existing pole line but only if alternate construction cannot be installed such as using swamp anchors, H-Fixture, or push and pull brace configurations which would be more desirable.

**Figure 6-24 Push and Pull Brace, and Double Pole Brace Configurations**

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Pole braces are attached to poles by means of the B Pole Brace Connector which consists of two identical galvanized malleable iron castings connected by a 3/4-inch machine bolt, acting as a hinge pin. It may be used on any class pole. Difficulty may be encountered with installation on small diameter poles such as Class 9 or 10.

The installation of pole braces generally follows the steps below:

- (a) With the brace lying on the ground one of the two parts of the hinged pole connector is fastened to the brace with a 5/8-inch bolt and a B Curved Washer through the bottom hole on the hinged pole connector and the top gain hole on the brace.
- (b) The second hole is then drilled in the brace to line up with the top hole in the connector, and the second 5/8-inch bolt and B Curved Washer installed.
- (c) With the completely assembled hinged pole connector in place, and the butt of the brace in the hole, the brace is held in final position against the pole and the pole marked for drilling.
- (d) The top of the brace is moved aside (but still held aloft by the derrick) and the holes drilled in the pole.
- (e) The 3/4-inch machine bolt is then removed from the hinged pole connector and the second half fastened to the pole with two 5/8-inch bolts and B Curved Washers as illustrated in the above figures.
- (f) The top of the brace is then swung back to the pole and the 3/4-inch machine bolt inserted and secured.
- (g) With brace secured to the line pole, firmly seat the butt of the brace with its anchor planks or log. Sandy soil, gravel, or small rock well tamped under and around the footings, followed by well tamped restoration of the excavation soil, will help prevent settling.
- (h) If a double pole brace is to be used, the second brace is installed similarly. The 3/4-inch machine bolt is removed from the second connector and one half of the connector is attached to the pole with the same bolts used to fasten the opposite connector. Do not use the B Curved Washers for this section connection. The other half of the connector is placed on the second brace. The brace is then raised to position and the connector reassembled with the 3/ 4-inch machine bolt.

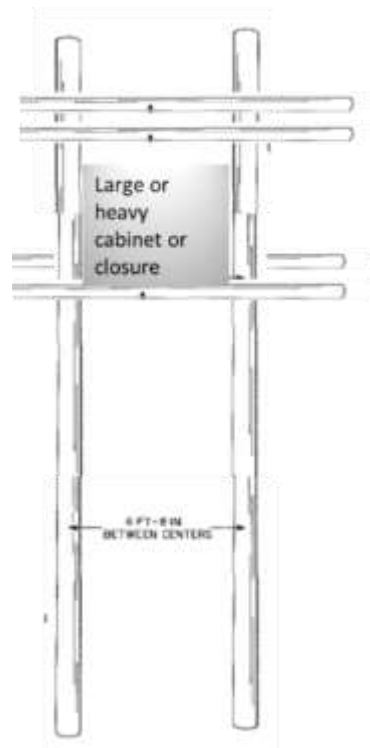
### 6.8.2 H-Fixtures

H-Fixtures can be used to substitute for storm guying, at certain corners or in unstable ground. H-fixtures were used more often in older plant where multiple crossarms carrying open communications lines and power lines were aligned along crossarms mounted on glass insulators (e.g., a 10-pin crossarm). The use of H-Fixtures at corners with large pulls may be desirable in certain cases. In general, however, the use of anchor guyed single poles is preferred. H-Fixtures set in unstable ground may require ground bracing to prevent the fixture from sinking in the ground.

H-Fixtures used as a substitute for storm side guyed single poles, provide a more substantial structure in the direction of the line and in some cases are more economical. The use of double crossarms is recommended at sites in the heavy and medium loading districts, in order to provide additional structural strength.

In recent times, H-fixtures may be used now as an option for mounting sizeable (heavy) cabinets that are too large for mounting on a single pole.

The recommended separation of the legs of the H-fixture is 6 to 7 feet measured center to center, between the two poles of an H Fixture is recommended. Both poles should be set vertically. A typical installation of a head-guyed H Fixture is shown in Figure 6-25.

**Figure 6-25 H-Fixture Type**

Ordinarily, the locations at which these fixtures are used do not permit the installation of a side guy other than a short lead guy extending from the pole on the inside of the corner to an anchor placed near the butt of the other pole. In determining the size of guy required, reduce the actual corner pull on the fixture by the amount shown in Table 6-9 for the length of pole in question. Use the reduced value of the corner pull in setting the guy rule.

**Table 6-9 Maximum Allowable Pull on H-Fixture at Corner [1]**

| <b>Length of Pole</b> | <b>Maximum Allowable Pull on H-Fixture at Corner, – where side guying may be omitted</b> |
|-----------------------|------------------------------------------------------------------------------------------|
| 25 feet or less       | 24 feet                                                                                  |
| 30 feet               | 20 feet                                                                                  |
| 35feet                | 16 feet                                                                                  |

**Note [1]** If the H-structure has more than 10 but less than 20 lines attached than these maximum allowable pulls should be halved.

For example, if it is desired to determine the size of guy required on a 30-foot pole having a pull of 20 feet, it will be found from the table that an H Fixture without guying may be used where the pull at the corner does not exceed 20 feet. Inasmuch as the amount of pull of corner on the pole exceeds 20 feet, guying is required on the amount of pull corner exceeding the 20 feet value.

H-Fixtures set in unstable ground (e.g., swamp) may require ground bracing or brace poles to prevent the fixture from sinking in the ground.

## 6.9 Grounding and Bonding of Guys

NESC Rule 215 requires a guy to be grounded or isolated. The objective of NESC Rules 215 and 233 is to not only help ensure that power fault current/voltage will not expose the public, supply workers, communications workers, or equipment to that power surge in normal operation, but also to help ensure that if a line conductor or guy goes slack the safety of public and workers continue to be protected from exposure (see Chapter 7).

Designers should attempt to position the insulator on a guy from the power space to avoid transfer of voltage to lower supply lines or communications lines if the guy becomes slack or broken. However given the multitude of lines on many poles, such insulator placement is not possible or practical in many situations and installations.

Since a wide variety of situations can develop by a broken or slack anchor guy, it is important for the communication messenger strand be bonded and grounded to help ensure a rapid operation of the supply system

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protective devices. Best practice work rules require a communication worker to test for voltage on poles, guys, and strands prior performing work which also mitigates the safety concern around “voltage transfer” from power space to communications space through slack or broken guys .

Communications guys are usually electrically bonded through their attachment hardware with the path to ground (earth) passing through one or more of the following:

- Anchors
- Strand/Messenger
- Metallic Pole Attachment Hardware
- Vertical Pole Ground Wires (MGNs).

The intent is for the communications equipment to be grounded through a permanent bond to the pole ground and supply neutral. A solidly attached guy forms a low impedance or low resistance connection to earth through the attachment hardware, strand and MGN connections. The interconnected system meets the definition of grounded (or “effectively grounded”) since it is designed to minimize hazard to personnel and have resistance or impedance to ground low enough to permit prompt operation of circuit protective devices. There is no need for additional bonding/grounding connections between the strand and the communications guy.

For more detailed discussions on grounding and bonding issues, refer to [Chapter 10](#), Plant, “and [Chapter 25](#), “[Bonding and Grounding - Drop Cables and Service Wires.](#)”

## 6.10 Non-Wood Poles

Although the guying information supplied in this section was developed for wood poles, the guidance and procedures described herein are all applicable to non-wood poles. The safe guying, measurement of lead/height ratio, determination of pull and positioning of the guy strand/anchor are all independent of the type of pole material.

For the light-weight tubular poles (i.e., fiberglass and steel), the correct guying and load balancing procedures are more important since their higher center of gravity and hollow construction can reduce structural robustness if residual torsional or flexural stresses are not properly minimized through appropriate guying methods and procedures.

As outlined in [Section 5.15](#), care and attention should be applied when choosing the correct attachment hardware for the guy to the non-wood pole to help ensure the maximum grip is achieved and maintained for the lifetime of the pole installation.

## 7 Insulating Guys

### 7.1 General

This chapter covers the methods of insulating guys with such guy strain insulators to help ensure that if a line conductor or guy goes slack, then power fault current/ voltage will not expose the public, supply workers, communications workers, or equipment to that power surge. NESC Rule 215 requires a guy to be grounded or isolated. Isolation is chiefly achieved through the use of ANSI C29 type insulators for purposes such as:

- To help prevent exposure of communications workers or the public to power line voltages if power conductors or guys break or become slack.
- Isolating a communications line from the effects of electrical induction and ground potential rise problems in the zone of protection around power substations.
- Isolating and protecting aerial plant in areas where soil is known to be corrosive to metal anchors and rods.

Strain insulators shall be placed only where required by local regulations or by specific conditions as shown in this chapter. The specific conditions illustrated show strain insulator locations in reference to zones of exposure. The hardware shown in the figures is typical. Other acceptable hardware, as explained in the text, may be used.

The voltage of power lines is sometimes expressed as voltage (phase-to-phase) between wires. When guy insulators are used, they must be adequate for the full voltage between conductors. Note that voltage between conductors of a 3-phase power system is 1.732 times the voltage to ground. For example, a 3-phase line carrying 14,400 V to ground has a voltage of 25,000 V between conductors. Guy insulators used on such a line must be rated for 25,000 V minimum.

The practice of insulating only for the single-phase voltage (i.e., voltage to ground) must, in general, be limited to single-phase spur lines serving a single customer on private property. Single-phase lines on through roads and other similar locations are likely to be reinforced with the second- and third-phase conductors as power loads grow. To avoid adding or replacing insulators, these lines must be considered as being 3-phase lines when selecting the size of the guy strain insulator.

Insulators in a guy strand used exclusively for the elimination of corrosion of metal ground rods, anchor rods, or pipe, in a grounded system shall not be classified as a guy insulator and shall not reduce the mechanical strength of the guy.

In general, the reader can reference Rules 215 and 279 of the NESC 2023 Edition for information on grounding and guy insulators with Rules 279A, 279A2, 277, 215C, and 215C4 specifically applicable to the insulating guys

discussed in this chapter. The mechanical and electrical strength of the guy insulators used in guys shall be verified with test data against ANSI C29.1 or ANSI C29.11. The power industry uses many guy insulator designs for the higher voltage circumstances. The guys used on communications guys are usually of the single fin design shown in [Section 7.2](#) ([Figure 7-1](#)) and are sometimes generically referred to as “Johnny Balls”.

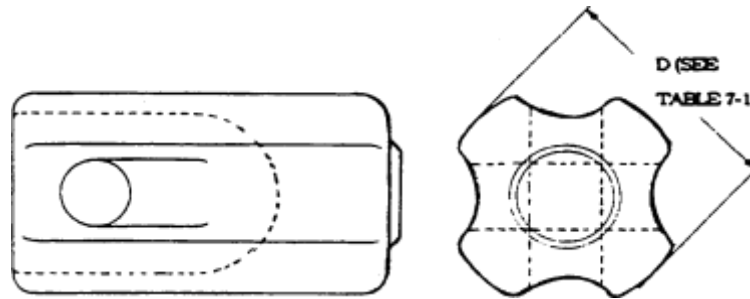
## 7.2 Sizes and Ratings of Strain Insulators

Selection of the proper size guy insulator is based on both the voltage of the power conductors creating the exposure and the size of the guy strand. [Table 7-1](#) lists the sizes of current standard commercial insulators and the conditions under which each may be used. These are called “single” fin-type insulators.

**Table 7-1 Strain Insulator Characteristics**

| Size of Guy      | Maximum Voltage | um Length (L) | um Diameter (D) |
|------------------|-----------------|---------------|-----------------|
| 10 M and smaller | 13,500          | 3-1/4 inch    | 2-3/8 inch      |
| 16 M and smaller | 15,000          | 4-1/8 inch    | 2-3/4 inch      |
| 25 M and smaller | 18,000          | 5-1/4 inch    | 3-1/4 inch      |

Their general appearance is shown in [Figure 7-1](#). Insulators are not necessarily marked to identify either their mechanical or electrical ratings. Guy strain insulators should be clearly and indelibly marked in accordance with ANSI C29.4, Section 7, with the manufacturer’s name or symbol, year of manufacture, and a product identification (catalog) number that will permit determination of the electrical and mechanical properties. However, ratings of guy insulators used for communications guys can be determined by measuring the length (L) and diameter (D) of insulators and comparing these measurements with the values listed in [Table 7-1](#).

**Figure 7-1 Strain Insulator - Single Line Type**

If it is necessary to insulate against voltages higher than the rating of a single insulator, use two or more insulators in series. For example, if it is necessary to insulate a 10 M guy against a 25,000 V exposure, use two 3-1/4 x 2-3/8 inch strain insulators. An exposure of 50,000 V requires three 5-1/4 x 3-1/4 inch insulators in series.

### 7.3 Locating Insulators

Where guys are arranged so one crosses or is above another, insulators must be located so that if one guy should sag down upon the other, the insulators will not become ineffective.

As per the NESC, strain insulators on anchor guys shall be installed and “positioned to limit the likelihood that any portion of the guy becoming energized within 8 feet of the ground level in the event that the guy becomes slack or breaks” (i.e., within reach of public). Since this criteria applies to a situation with slack or broken guys, the insulator needs to be placed sufficiently high so in the case where the anchor guy breaks, any possible conductive part of the insulator is more than 8 feet above ground. Depending on the Lead-over-Height ratio, the bottom of the insulator as installed on the guy may be required to be located a considerable distance along the guy from the anchor point to ensure that when broken, the insulator shall still be at least 8 feet above ground level.

The general installation sequence for placing an insulated anchor guy provides an opportunity during step 4 to readily meet the 8 feet, as follows:

1. After determining the direction of pull and the required sizes as per [Chapter 6](#) of this *Blue Book*, place the anchor and rod in the ground following the guidelines in [Chapter 8](#).
2. Attach guy hook to the pole with appropriate hardware (usually 5/8 or 3/4 hardware) using the set anchor to guide the drill hole (see [Chapters 5](#) and [6](#) for pole and guy hardware choices).
3. Position guy around guy hook on the pole.

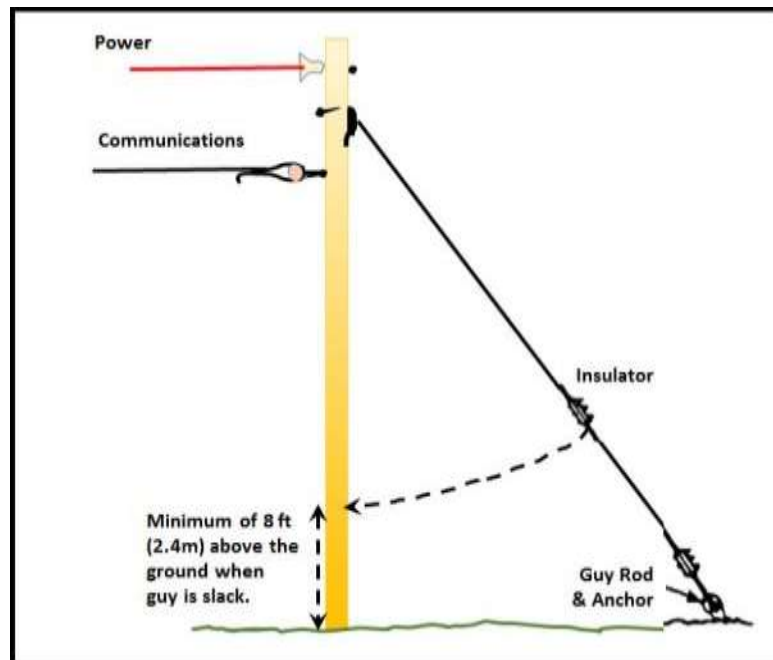
4. Add insulator into guy (see [Section 7.4](#)).

With the guy lying slack along the pole, the insulator can be placed so that the bottom of the insulator is located at least 8 feet above ground, after which the bottom portion of the guy can be moved over to the anchor/rod.

5. Secure the guy to the rod using the appropriate hardware, assuming that the technician uses a strand grip (wrap around) and three bolt clamp. See other chapters (e.g., Chapters [5](#), [6](#) and [8](#)) of this *Blue Book* for guidance on appropriate hardware choices and configurations.

A minimum height in any of these rules does not prohibit the insulator from being placed higher and even above the communications line height to help prevent transfer of supply voltage/current onto communications lines in case of a broken or slack anchor guy. The reference 8-foot height is based on the maximum reach of a person. The 8-foot value to define if structures not readily climbable as well as for the height above ground of the insulator is a realistic and practical value.

**Note:** It is anticipated that over the next code cycles (2028 code cycle), there may be change proposals to increase the minimum heights above the ground.



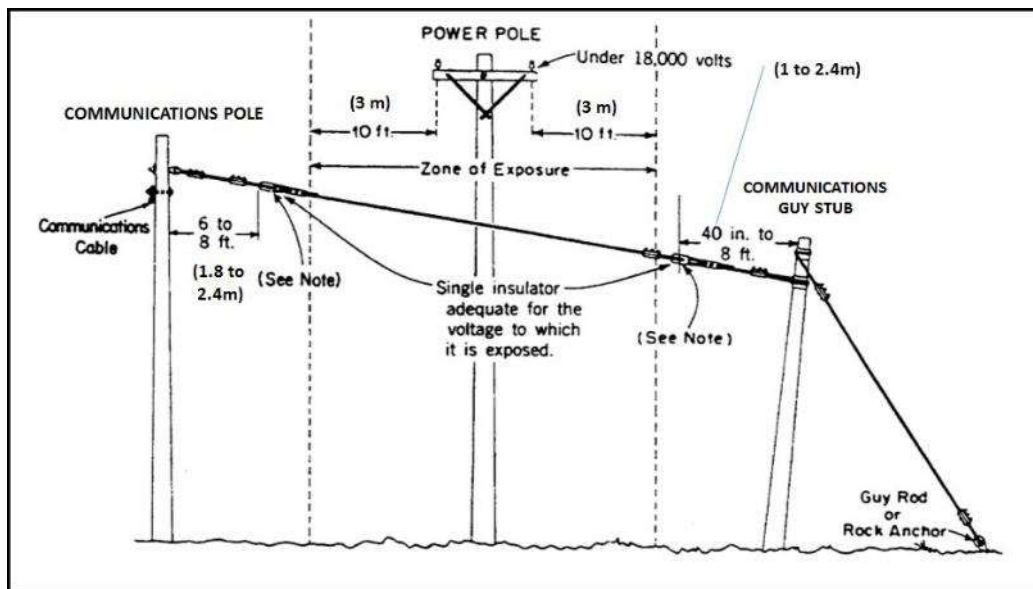
If the guy extends through communications space into the power space, an additional insulator on the guy may be required to help prevent contact between an energized guy and the communications lines or messenger

strands (see [Figure 7-5](#) as an example).

On non-joint poles, guy strain insulators in pole-to-pole or stub guys shall be located outside the zone of exposure, as shown in [Figure 7-2](#) and [Figure 7-3](#). The zone of exposure is defined as the space that is within a horizontal distance of 10 feet from a power conductor and extends both above and below the conductor. Strain insulators in anchor guys must be located outside the zone of exposure.

Guy strain insulators shall be located to obtain the horizontal clearances from a pole as shown in [Table 7-2](#).

**Figure 7-2 Location of Strain Insulators on Pole-to-Pole and Anchor Guys in Exposure Zones for Supply Lines of 18 kV or Under**



**Note:** Do not place strain insulators within the zone of exposure.

**Figure 7-3 Location of Strain Insulators on Pole-to-Pole and Anchor Guys - Zones Above 18,000 V**

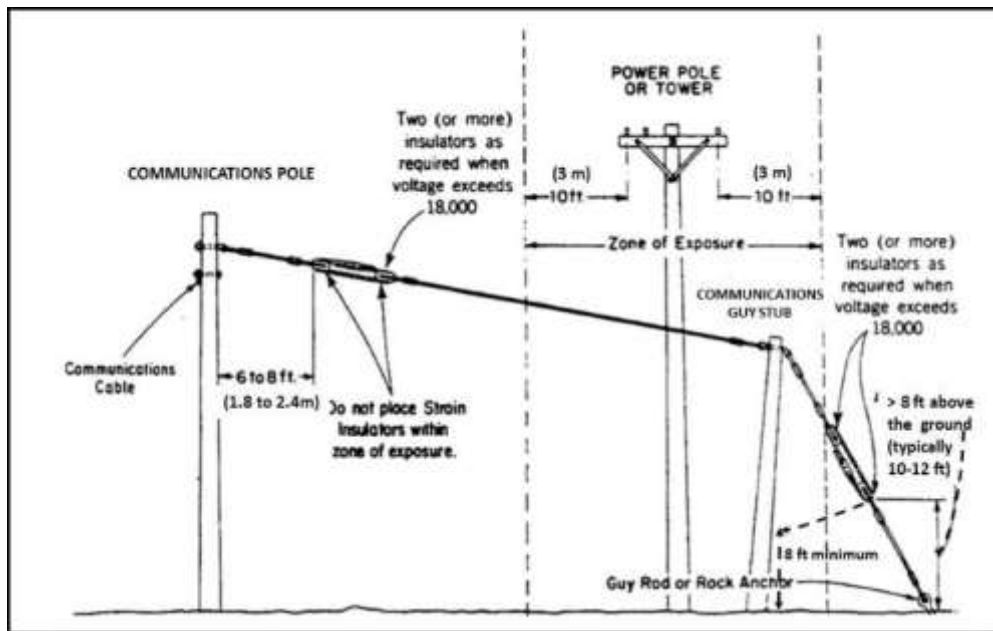


**Table 7-2 Guy Strain Insulator Locations**

| Kind of Guy                  | Horizontal Clearance if Pole Carries     |                                         |
|------------------------------|------------------------------------------|-----------------------------------------|
|                              | Cable or Multiple Line Wire              | Open Wire                               |
| Anchor                       | 40 inches - if practical<br>(1 meter)    | 40 inches - if practical<br>(1 meter)   |
| Pole-to-Pole or Pole-to-Stub | 40 inches to 8 feet<br>(1 to 2.4 meters) | 6 feet to 8 feet<br>(1.8 to 2.4 meters) |

On poles carrying trolley feeders below communications attachments, place two strain insulators so one will be above the trolley feeder and one will be below. The upper insulator must be located 6 to 12 inches above the level of the trolley feeders. Avoid grounding the upper part of the guy (Figure 7-4). On poles carrying trolley feeders above communications attachments, place a single insulator in accordance with this section unless other existing power facilities require that two or more insulators must be used.

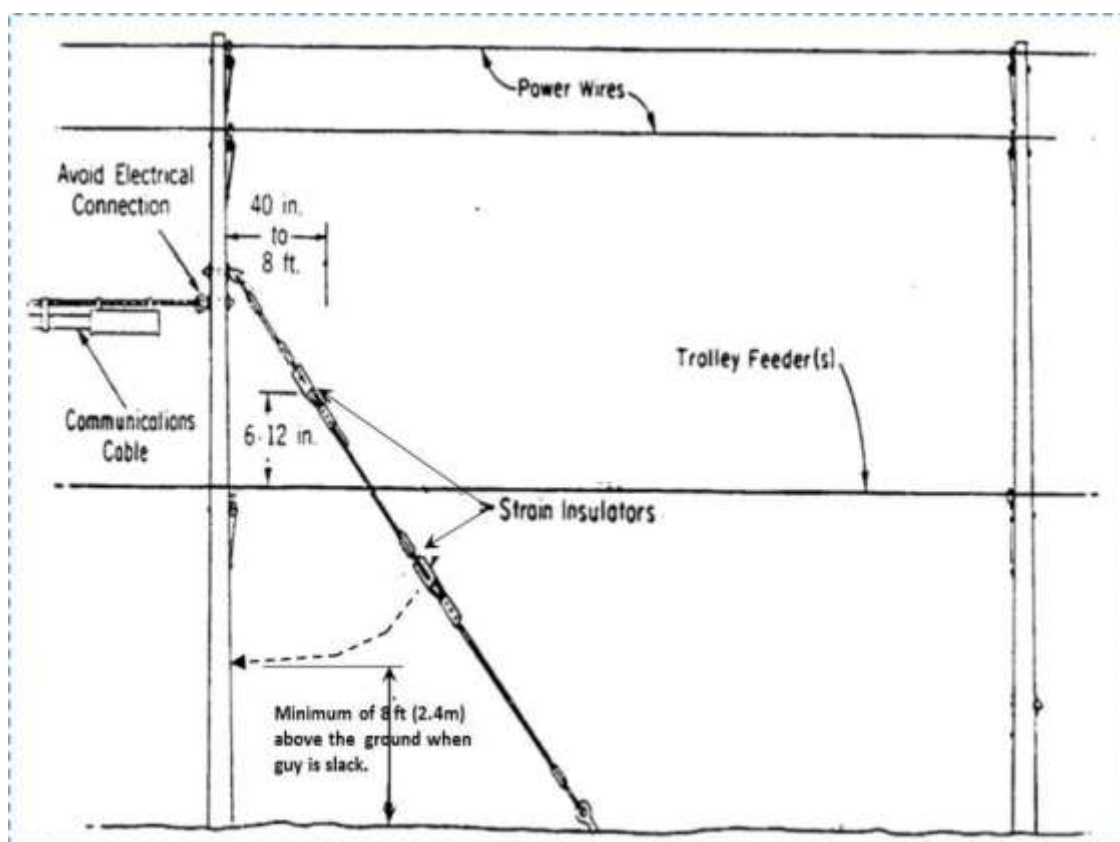
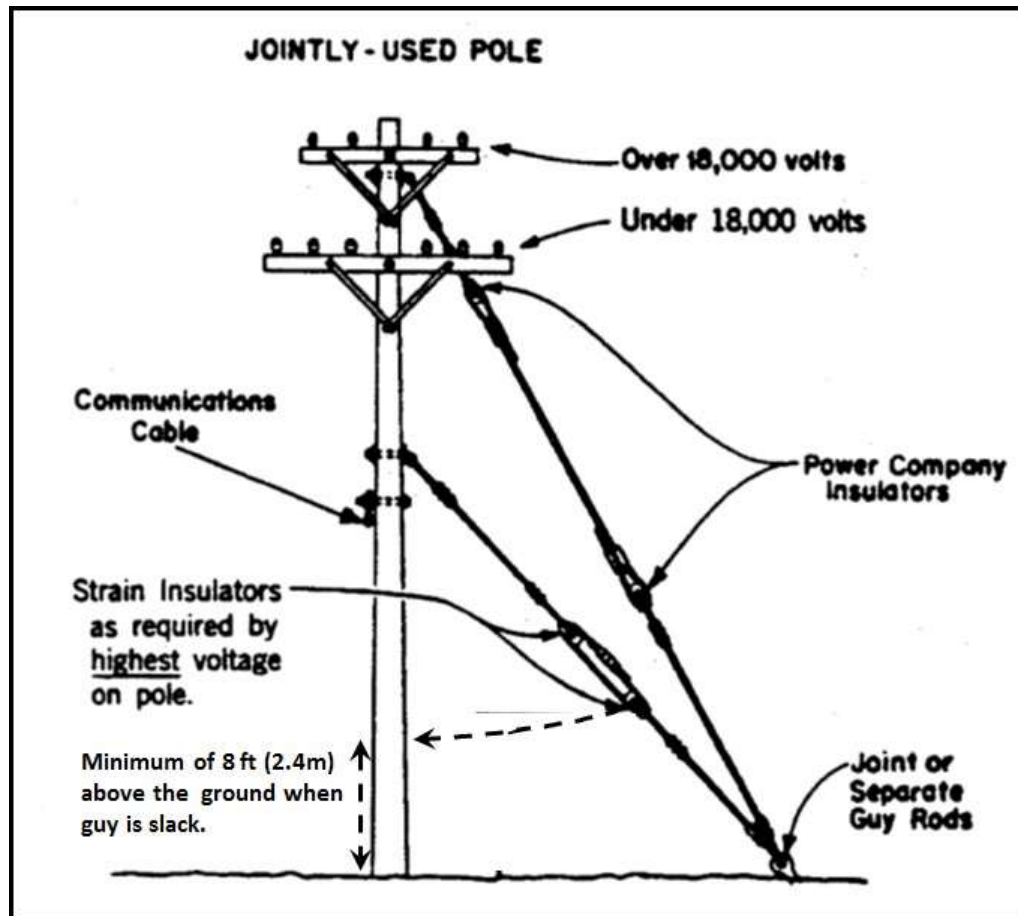
**Figure 7-4 Location of Strain Insulators on Poles Carrying Trolley Feeders**

Figure 7-5 shows the locations for strain insulators in anchor guys on jointly used poles.



**Figure 7-5 Location of Strain Insulators in Anchor Guys on Jointly Used Poles**

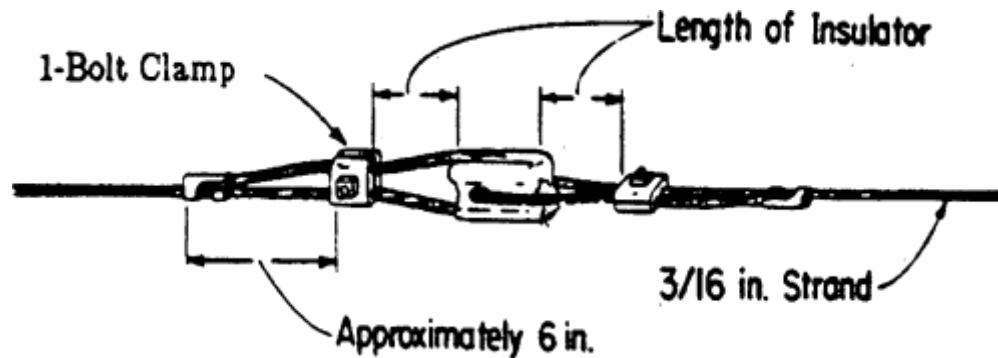
Near some power stations, the cable sheath must be isolated from the effects of ground potential rise. Where these conditions exist, strain insulators shall be placed in the guys.

## 7.4 Methods of Installing Strain Insulators

Strain insulators shall be installed as follows:

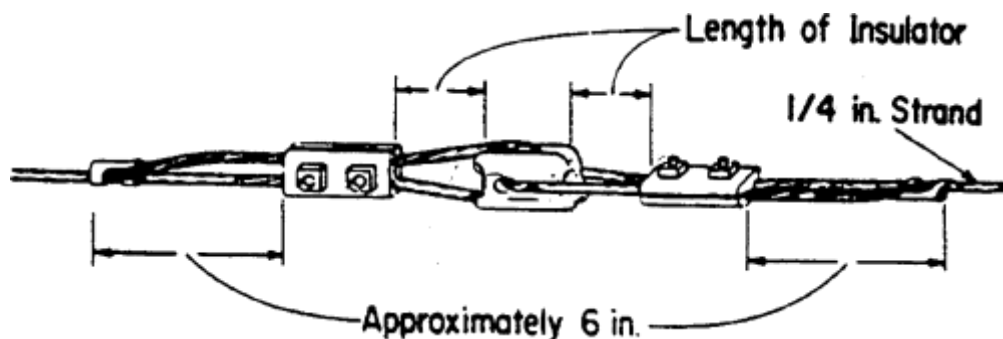
- **2.2 M Strand:** Use a 1-bolt clamp on each side of the insulator ([Figure 7-6](#)).

**Figure 7-6 Strain Insulator Installation with Two 1-Bolt Clamps**



- **6.6 M Strand:** Use one 2-bolt clamp, strand grip, or long bail strandwise on each side of the insulator ([Figure 7-7](#)).

**Figure 7-7 Strain Insulator Installation with Two 1-Bolt Clamps**

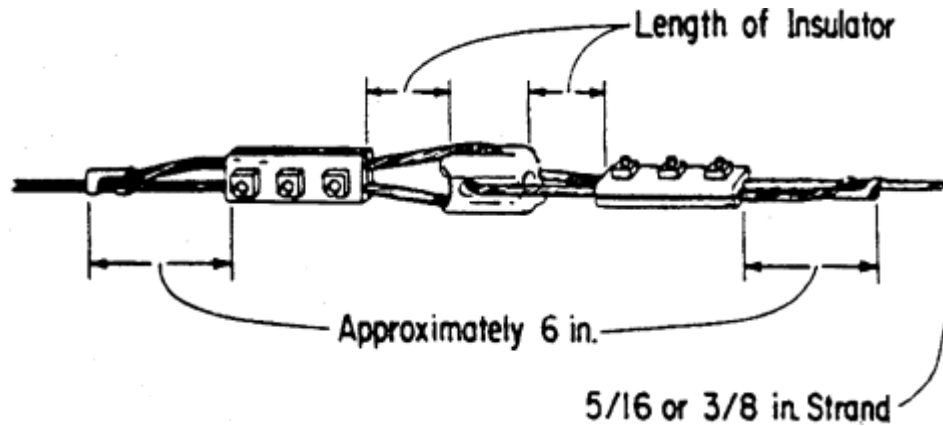


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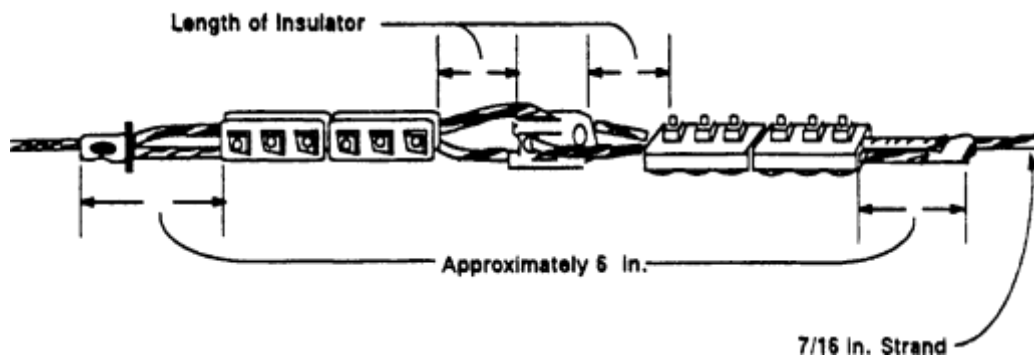
- **6 M and 10 M Strand:** Use one 3-bolt clamp, strand grip, or long bail strandvice on each side of the insulator (Figure 7-8). Tightening the bolts on 3-bolt clamps should preferably be done with the clamps held in a vise.

**Figure 7-8 Strain Insulator Installation with Two 3-Bolt Clamps**



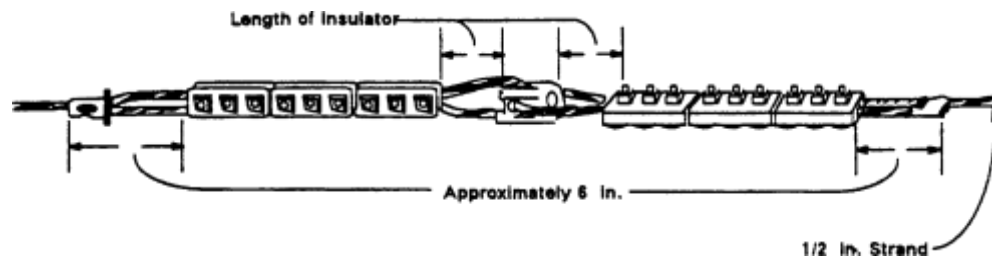
- **16 M Strand:** Use two 3-bolt clamps on each side of the insulator. Long bail strandvice or strand grips may be used, one on each side of the insulator (Figure 7-9).

**Figure 7-9 Strain Insulator Installation With Four 3-Bolt Clamps**



- **25 M Strand:** Use three 3-bolt clamps on each side of the insulator. Strand grips may also be used ([Figure 7-10](#)).

**Figure 7-10 Strain Insulator Installation with Six 3-Bolt Clamps**



- **Strain Insulators in Series:** Strand grips and guy connectors may be used as shown in [Figure 7-11](#). An alternative method is to use 3-bolt clamps and strand as shown in [Figure 7-12](#) to close the loop that connects the insulators.

**Figure 7-11 Strain Insulator Installed in Series Using Guy Connector**

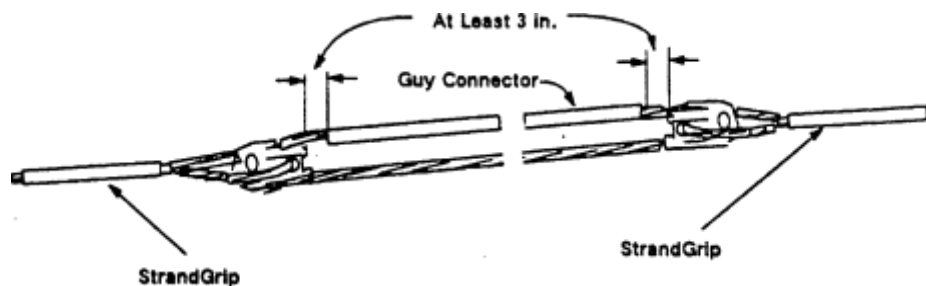
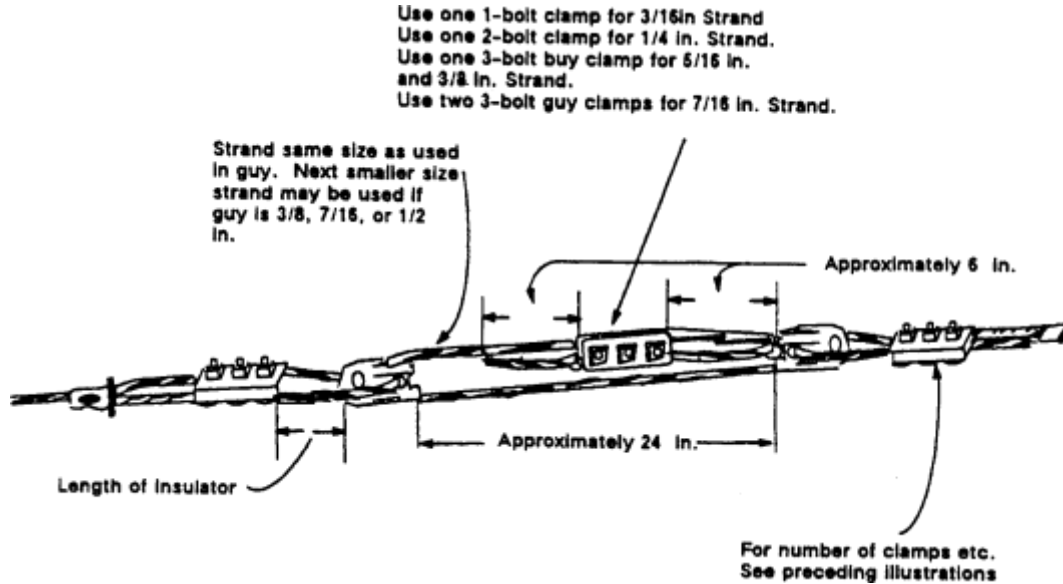


**Figure 7-12 Strain Insulator Installed in Series Using 3-Bolt Clamps**

Insulators placed as shown in [Figure 7-12](#) shall be connected with loops of strand sizes not less than those shown in [Table 7-3](#).

**Table 7-3 Strand Loop Sizes**

| Size of Guy Strand | Size of Strand in Loop |                  |
|--------------------|------------------------|------------------|
|                    | M Size                 | Nominal Diameter |
| 6.6 M              | 6 M                    | 5/16 inch        |
| 6 M                | 6 M                    | 5/16 inch        |
| 10 M               | 6 M                    | 5/16 inch        |
| 16 M               | 10 M                   | 3/8 inch         |
| 25 M               | 16 M                   | 7/16 inch        |

## 7.5 Normative and Informative References Related to Pole Hardware

1. ANSI/NEMA C29.1, *Test Methods for Electrical Power Insulators*.
2. ANSI/NEMA C29.11, *Composite Suspension Insulators for Overhead Transmission Lines – Tests*.

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## 8 Anchors and Guy Rods

### 8.1 General

This chapter covers the descriptions and use of anchors and guy rods for terminating guy strand under various conditions. Types of anchors available include:

- Expanding anchors
- Screw anchors
- Toggle anchors
- Plate anchors
- Rock anchors
- Swamp anchors.

The appropriate uses of these various types of anchors are covered in [Section 8.2](#). Expanding anchors, screw anchors, and toggle anchors, the types most frequently used, are covered in detail in [Section 8.4](#), [Section 8.5](#), and [Section 8.7](#), respectively.

The other types that are infrequently used are not covered as thoroughly. A licensee shall not place anchors that will negate the holding power of existing communications company or power supply company anchors.

The position of the anchor is determined by available space in the rights-of-way or easement, the lead/height ratio, and the tension required on the guy wire. Although there is no separation requirement in the NESC between two anchors from a single structure, it is recommended that a minimum distance of 2 feet be maintained between separate anchors to avoid possible conflicts with the underground anchor rods. In many cases, two or more guys can often share an anchor to reduce the installation costs.

In some cases, the guy rods associated with anchors have more than one eye for attaching guy strands. Where the communications company has an existing guy rod with adequate strength to accommodate the additional load and there is a spare eye, a licensee may request a permit to use the existing rod. In some cases, an existing communications company rod may have sufficient strength to permit attaching an additional guy strand, but does not have a spare eye. With a permit from the communications company, a guy rod clamp can be installed on the existing rod for terminating the additional guy strand.

In any specific situation where the licensor is unable to grant the licensee a permit to attach a guy to the licensor's anchor rod, the licensor will explain and document the reason(s) for such refusal.

The licensee shall secure any necessary permit from the appropriate federal,

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state, county, or municipal parties, or private property owners, to construct and maintain any guys that the licensee attaches to the licensor's anchor rods.

**Note:** The licensee must not attach a guy strand to a communications company guy rod without first obtaining a permit from the licensor. If the communications company should subsequently require the space or capacity of a rod that was used to terminate a licensee guy, the licensee will have to relocate its guy in accordance with the provisions of the license agreement.

## 8.2 Field of Use

### 8.2.1 Average Soils

Expanding-type, plate-type, and screw anchors are generally satisfactory for use in the large variety of soils encountered ranging from extremely hard to soft or loose soils. Screw anchors are power installed and have the advantage of requiring a minimum of earth disturbance for installation.

Correct installation procedures for expanding anchors are covered in [Section 8.4](#). Screw anchors are covered in [Section 8.5](#), and toggle anchors are covered in [Section 8.7](#).

### 8.2.2 Rock Formations

Rock anchors are used in areas where solid rock or bedrock formations such as hard basalts, lava formations and some sandstones make it impractical to use a screw or an expanding-type anchor. Rock anchors are installed in carefully drilled 2-1/6 inch diameter holes. Rock anchors (B-type and D-type) have an integral wedge that solidly forces plates against the inside wall of the drilled hole and provides the primary anchoring for the guy.

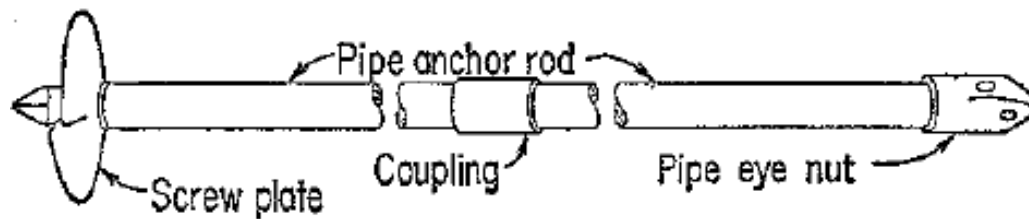
If the rock is badly decomposed or broken-up rock, then the drilled holes are likely to not provide a satisfactory hole for a B-type rock anchor since during the installation the surrounding rock may crack. In such a case, one may need to use either (1) a D-type anchor installed in a 1-1/16 inch diameter hole oriented perpendicular (90 degrees) to the direction of the guy, or (2) a guy rod with a nut attached at the bottom end cemented securely in place in a 2-1/4 inch diameter hole. These alternative procedures should only be employed after consultation with a local communications company engineer.

### 8.2.3 Swampy Areas

Swamp anchors are used in swampy, marshy or other water-saturated areas. They are screw-type anchors consisting of a helical plate and an iron pipe used instead of a guy rod, and a pipe eye nut that attaches to the top of the pole to accept the guy strand.

The screw plates on swamp anchors that are suitable for the 6 M to 16 M guys have typical diameters ranging from 10 to 15 inches, and the iron pipes are 1-1/2 to 2 inches in diameter, as follows:

- 6 M or 6.6 M -- 10-inch plate and 1-1/2 inch pipe
- 10 M -- 12-inch plate and 2-inch pipe
- 16 M -- 15-inch plate and 2-inch pipe.



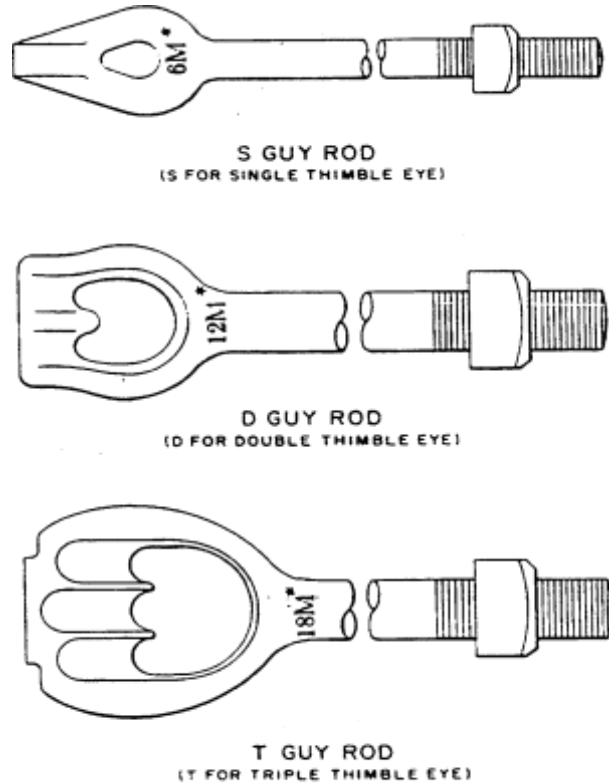
If guy wire and swamp anchors configurations do not provide inadequate support in swamps and marsh areas, one alternate is to use brace poles and H-fixtures (see Section 6.8) to support the pole.



### 8.3 Description of Guy Rods (With Expanding Anchors)

Guy rods used with expanding anchors are made of galvanized steel having an integral single, double, or triple thimble eye, as shown in [Figure 8-1](#). They are available in diameters of 1/2 inch, 5/8 inch, 3/4 inch, 1 inch, and 1-1/4 inches.

**Figure 8-1 Types of Guy Rods**



\* — Indicates guying load capacity allowed on rod. For unmarked rods, refer to Table 8-1.

**Table 8-1 Unmarked Guy Rods (Used with Expanding Anchors)**

| Diameter (Inch) | Length (Feet) | Equivalent Strand Size |
|-----------------|---------------|------------------------|
| 1/2             | 7             | 2.2 M                  |
| 5/8             | 8             | 6 M or 6.6 M           |
| 3/4             | 9             | 16 M                   |
| 1               | 10            | 26 M                   |
| 1-1/4           | 10            | 32 M                   |

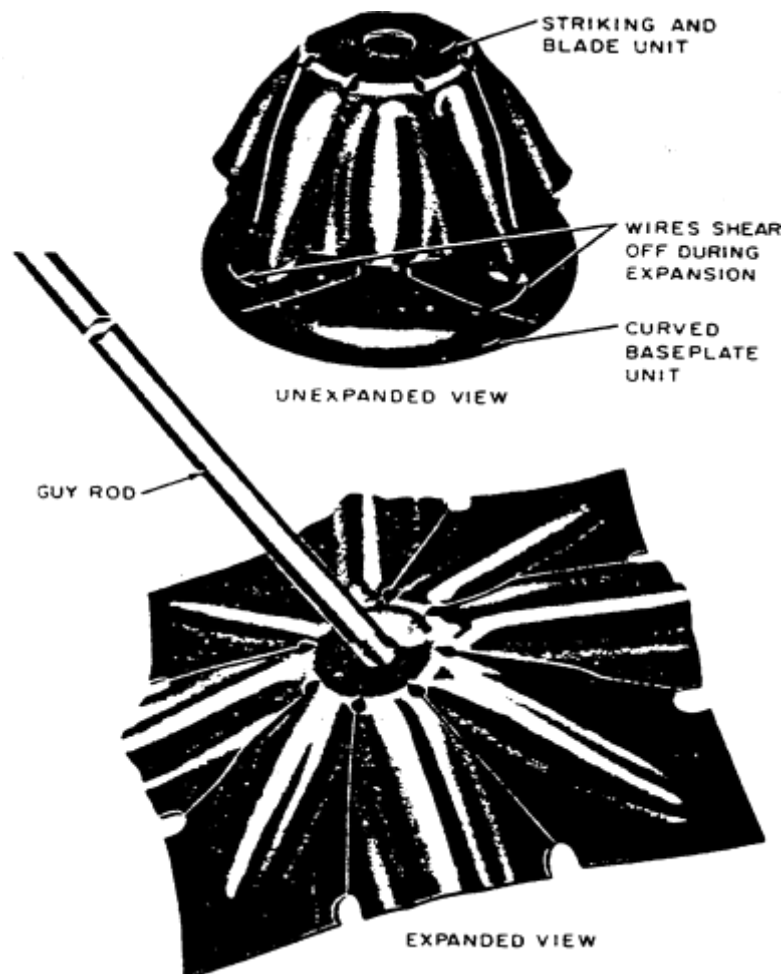
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## 8.4 Expanding Anchors

Figure 8-2 shows an inclined 8-blade-type expanding anchor. It is available in sizes capable of holding tensions of 6,000 to 32,000 pounds. A pincer-type nut retainer is welded to the underside of the base to retain the guy rod nut. Expanding anchors are best in average soils and should not be used in swampy or loosely compacted soils.

**Figure 8-2 Expanding Anchor**



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Table 8-2 lists the following:

- a. Size and type of the 4-, 6-, and 8-way type expanding anchors
- b. Guy rods that each specific size anchor will accommodate
- c. Maximum strand sizes to be used for the combinations of anchor, guy rod, and guy strand for the most common plant configurations.

**Note:** The size of the hole required for placing the anchor is the same as the diameter of the anchor.

**Table 8-2 Sizes of Anchors, Guy Rods, and Associated Guy Strands**

| Anchor         |          | Guy Rod    |         |             |                        | For Use With Guy Strand Size<br>Note [1]                                                              |
|----------------|----------|------------|---------|-------------|------------------------|-------------------------------------------------------------------------------------------------------|
| Type           | Diameter | Diameter   | Length  | Rod Marking | Thimble Eye            |                                                                                                       |
| 8-Way          | 6 inch   | 1/2 inch   | 7 feet  | 6 M         | Single Only            | one 2.2 M<br>or one 6 M<br>or one 6.6 M                                                               |
| 8-Way          | 8 inch   | 5/8 inch   | 8 feet  | 12 M        | Double Only            | one 10 M<br>or two 6 M<br>or two 6.6 M                                                                |
| 4-Way<br>8-Way | 10 inch  | 3/4 inch   | 9 feet  | 18 M        | Double<br>or<br>Triple | one 16 M<br>or one 6 M + one 10 M<br>or one 6.6 M + one 10 M<br>or three 6 M<br>or three 6.6 M        |
| 6-Way          | 12 inch  | 1 inch     | 10 feet | 26 M        | Double<br>or<br>Triple | one 25 M<br>or two 10 M<br>or one 10 M + one 16 M<br>or one 10 M + two 6 M<br>or one 10 M + two 6.6 M |
| 6-Way<br>8-Way | 12 inch  | 1-1/4 inch | 10 feet | 32 M        | Double<br>or<br>Triple | two 16 M<br>or three 10 M                                                                             |

**Note [1]** Other combinations may be used if they do not exceed the maximum load.

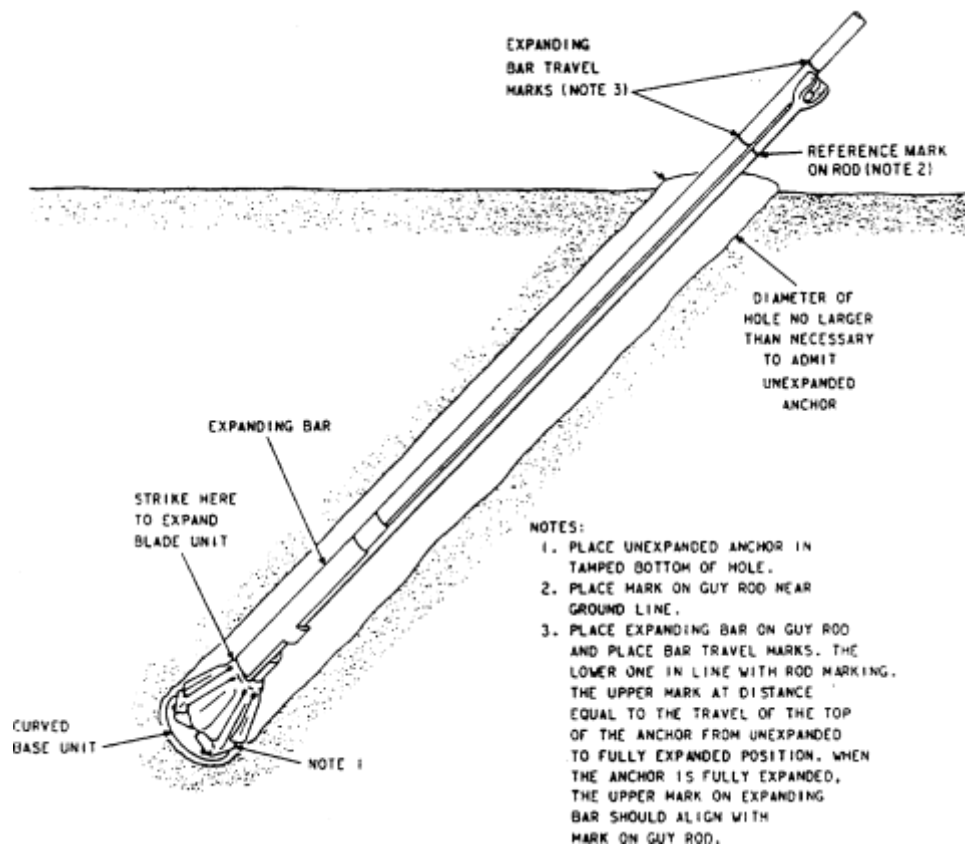
### 8.4.1 Installation

The wires used to hold the blades to the anchor base plate must not be removed. These wires will shear off during the expanding process.

Where practical, use earth augers to bore the hole for the anchor. Expanding anchors develop most of their holding power by the blades engaging undisturbed earth. Therefore, it is important that the hole is no larger than necessary to admit the unexpanded anchor.

It is preferable to dig an anchor hole at an angle, as shown in [Figure 8-3](#).

**Figure 8-3 Placing Anchor in Angled Hole**



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When soil conditions do not permit digging at an angle, dig a vertical hole and cut a slot as shown in [Figure 8-4](#). The slot should be made before the anchor is placed in the hole. The approximate dimensions of the hole and slot for a lead-over-height ratio of 1/2 and 1 are shown in [Table 8-3](#).

The placing guidance in [Figure 8-4](#) for “not less than 6 inch” exposure of the rod above ground is chosen to help ensure that the rod has been driven sufficiently deep to provide a solid anchor point for the guy strand. There are load devices that quantitatively measure and verify anchor strength (see [Section 8.9](#)). However, if the proper type, size and length of an anchor/rod combination is used that match the soil/rock type, then based on experience, if the rod is driven so that between 6 to 18 inches is above ground, one can confidently assume that the anchor is adequate for the expected load. If the exposed rod is short (< 6 inch), then concerns may arise about soil contamination of, and abrasive damage to, the strand from contact with rocks and other surface debris. If the exposed rod portion is long (e.g., >18 inches), then concerns arise that the anchor is not sunk deep enough and may become a trip hazard since the yellow guy marker does not extend below the eye.

**Figure 8-4 Placing Anchor in Vertical Hole With Slot**

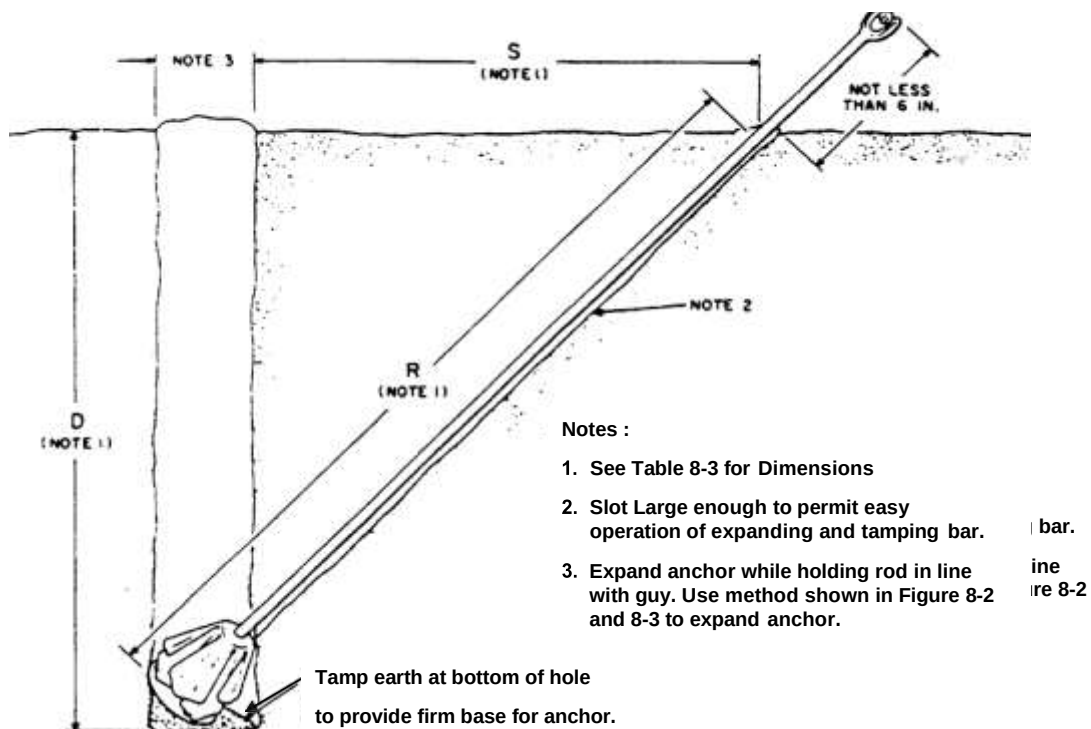
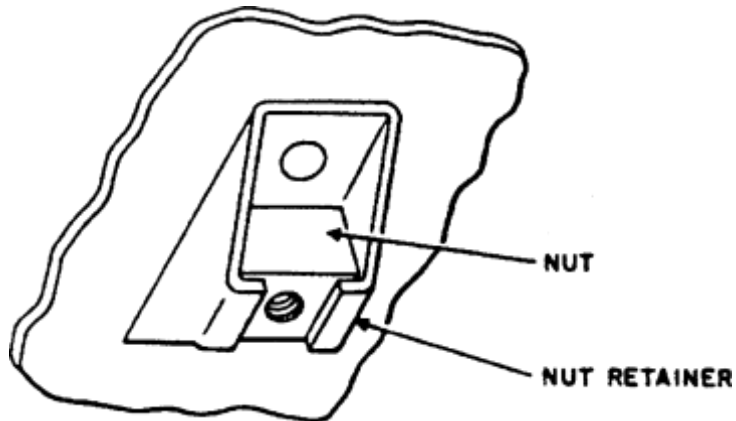


**Table 8-3 Anchor Placement Measurements (for Figure 8-4)**

| Length of Rod Feet | Lead Height = 1 |                |                | Lead Height = 1/2 |                |                |
|--------------------|-----------------|----------------|----------------|-------------------|----------------|----------------|
|                    | R<br>feet-inch  | D<br>feet-inch | S<br>feet-inch | R<br>feet-inch    | D<br>feet-inch | S<br>feet-inch |
| 6                  | 5-6             | 3-11           | 3-11           | 5-0               | 4-6            | 2-3            |
| 7                  | 6-6             | 4-7            | 4-7            | 6-0               | 5-5            | 2-8            |
| 8                  | 7-6             | 5-4            | 5-4            | 7-0               | 6-4            | 3-1            |
| 9                  | 8-6             | 6-0            | 6-0            | 8-0               | 7-2            | 3-7            |
| 10                 | 9-6             | 6-8            | 9-0            | 9-0               | 8-1            | 4-0            |

Place the guy rod nut into the nut retainer as shown in [Figure 8-5](#). Insert the threaded end of the rod into the opening in the top of the anchor to engage the nut. Turn the rod until the nut is tight against the anchor.

**Figure 8-5 Nut Retainer on Underside of Expanding Anchor**

Expand the anchor with an expanding bar or equivalent tool, as explained in the [Figure 8-3](#) notes.

During the backfill operation, the earth should be tamped down firmly throughout the depth of the hole by filling and tamping in steps. For example, (1) add 12-18 inches of fill, (2) firmly tamp down fill, and (3) repeat 1 and 2 until the hole is filled and tamped down to be flush with the surrounding area. One can over-fill the hole to leave a mounded section that allows for settling over time or return 48 hours after the installation to re-fill the hole and re-tamp the fill flush with the surface if any settling has occurred.

## 8.5 Screw Anchors

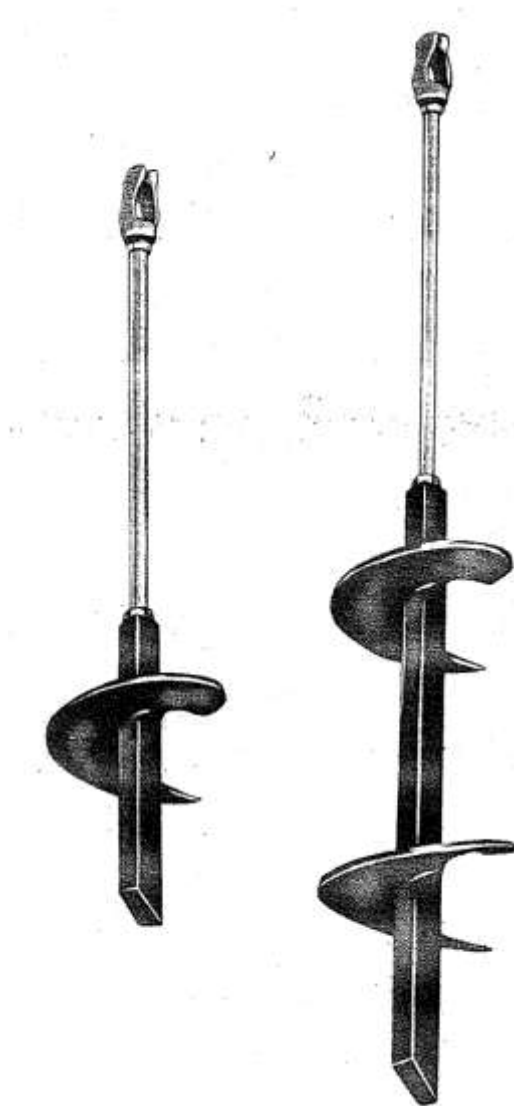
The screw anchor shown in [Figure 8-6](#) is a typical wrench-type anchor designed for installation with a power digger. A screw anchor wrench ([Figure 8-7](#)) that fits over the anchor hub and a torque measurement device are required to properly install the anchor. Screw anchors are best in rock-free soils such as moist clay or loam. They should be avoided in rocky soils, shales or hardpan areas.

**Note:** *Hardpan* is an area with an impervious layer, typically of hard clay, occurring in or below the surface soil that impairs drainage and plant growth.

Proper selection depends on the type of soil and the guying requirements.

Screw anchors are available in a variety of helix configurations, rod sizes, and thimble eyes. The double helix or twin type is often preferred over the single helix type since it covers more soil types and application situations (e.g., more versatile choice). The correct installation is achieved only when the anchor is installed using the appropriate torque for the particular soil and anchor type as recommended by the manufacturer. Installation torque is usually measured using a device connected in series with the wrench and digger kelley bar during installation. The digger torque capacity and hub strength of the anchor must be compatible with the torque values required for anchor installation.

**Figure 8-6 Single and Twin Helix Anchors**

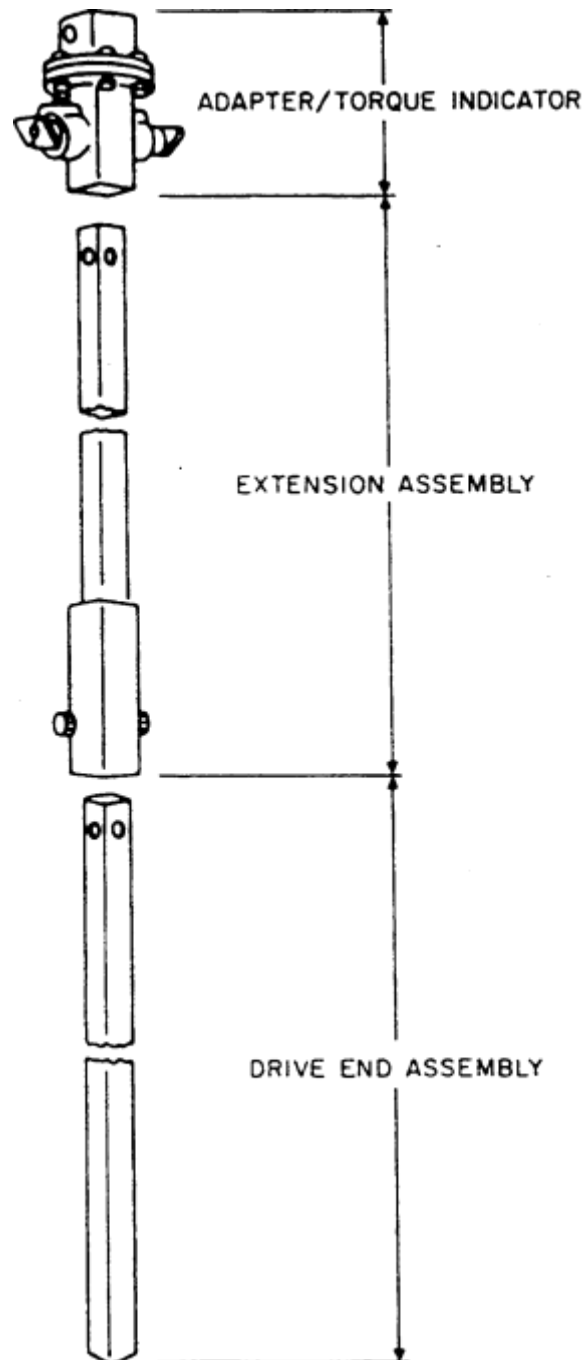


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**Figure 8-7 Screw Anchor Wrench**

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Screw anchors must always be installed so that the maximum load capability of the rod size used can be accommodated. Typical data on screw anchors is shown in [Table 8-4](#).

Table 8-4 Screw Anchors

| Soil Grade<br>(See <a href="#">Table 8-5</a> ) | Anchor [Note 1] |                      | Rod Size Marking<br>[Note 2] | Eye Nut | Maximum<br>Guying Load<br>[Note 3] |
|------------------------------------------------|-----------------|----------------------|------------------------------|---------|------------------------------------|
|                                                | Size            | Type                 |                              |         |                                    |
| 2                                              | 5               | Twin 4               | 1" Dia / 32 M                | Triple  | Up to 32 M                         |
| 2                                              | 6               | Single 8<br>[Note 4] | 1" Dia / 32 M                | Triple  | Up to 32 M                         |
| 2                                              | 3               | Twin 8               | 1" Dia / 32 M                | Triple  | Up to 32 M                         |
| 2                                              | 6               | Single 8             | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 3                                              | 1               | Twin 10              | 1" Dia / 32 M                | Triple  | Up to 32 M                         |
| 3                                              | 4               | Twin 8               | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 3                                              | 7               | Single 8             | 5/8" Dia / 12 M              | Double  | Up to 12 M                         |
| 4                                              | 1               | Twin 10              | 1" Dia / 32 M                | Triple  | Up to 32 M                         |
| 4                                              | 4               | Twin 8               | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 4                                              | 7               | Single 8             | 5/8" Dia / 12 M              | Double  | Up to 12 M                         |
| 5                                              | 4               | Twin 8               | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 5                                              | 2               | Twin 10              | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 5                                              | 7               | Single 8             | 5/8" Dia / 12 M              | Double  | Up to 12 M                         |
| 6                                              | 2               | Twin 10              | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |
| 7                                              | 2               | Twin 10              | 3/4" Dia / 18 M              | Double  | Up to 18 M                         |

- Note:** [1] The anchor size (helix configuration) recommended by the manufacturer will depend on the type of soil.
- [2] Rod size markings are stamped below the threads on the eye nut end of the rod. See [Figure 8-1](#).
- [3] The entries in this column represent the maximum guying load only when installed in accordance with the manufacturer's recommendations as to anchor size and installation torque. Combinations may not exceed the maximum load.
- [4] Size 5 - Twin 4 anchor must be used only where Size 6 - Single 8 cannot be used. Always attempt to use Size 6 - Single 8 in difficult soils before choosing Size 5 - Twin.

A 9-inch diameter helix anchor (1/2 inch rod) buried to a minimum depth of 7 feet is the smallest anchor system used for a 6M or greater strand/guy.

During installation the anchor should be tested when tensioned on the guy – any significant movement to lift the anchor should be reason to re-consider its use. Some helix anchor installation devices have torque measurements or break-away devices to help evaluate the guy/anchor support system. Field surveys of poles that reveal slack guys or leaning poles are some of the common indications of possible failed anchors.

### Small Screw Anchors –

In older plant, small screw anchors may be found used with 2.2M strands or galvanized wire guys. These small screw anchors are defined to be 6-to-8 inch diameter helix anchors installed with vertical set depths of 5 to 6 feet. These small screw anchors are to be used for only 2.2M – no larger or stronger guys. For example, an 8 inch diameter anchor (buried to 5 feet) has a 50 sq.in. area of helix (~27% less than a 9-inch diameter one) and 30% less depth (5 feet versus 7 feet). The soil volume that provides the primary anchoring would therefore be ~50% less for the 8 inch diam/5 ft deep anchor compared to the smallest one in the BSP table above. This would imply that these anchors would be good for 3000-4000 lbs load – significantly less than the breaking strength of 6M or 6.6M strand.

## 8.6 Soil Classes

Table 8-5 describes the approximate soil classifications. The determination of soil holding or supporting capacity is complex; therefore, this table should only serve as a guide.

**Table 8-5 Soil Class Definitions**

| <b>Soil Class</b> | <b>Description of Soil</b>                                                                        |
|-------------------|---------------------------------------------------------------------------------------------------|
| 1                 | Extremely hard - bedrock                                                                          |
| 2                 | Very hard - dense clay, compact gravel, dense fine sand, laminated rock, slate, schist, sandstone |
| 3                 | Hard - shale, broken bedrock, hardpan, compact clay-gravel mixture                                |
| 4                 | Gravel, compact gravel and sand, claypan                                                          |
| 5                 | Medium-firm clay, loose sand and gravel, compact coarse sand                                      |
| 6                 | Soft plastic clay, loose coarse sand, clay-type silt, compact fine sand [Note 1]                  |
| 7                 | Fill, loose fine sand, wet clays, silt                                                            |
| 8                 | Swamp, marsh, saturated silt, humus [Note 2]                                                      |

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- Note:** [1] Includes areas only seasonally wet with slow drain, as in fairly flat terrain.
- [2] Install anchors deep enough, by using extensions, to penetrate a Class 5, 6, or 7 soil underlying the Class 8 soil.

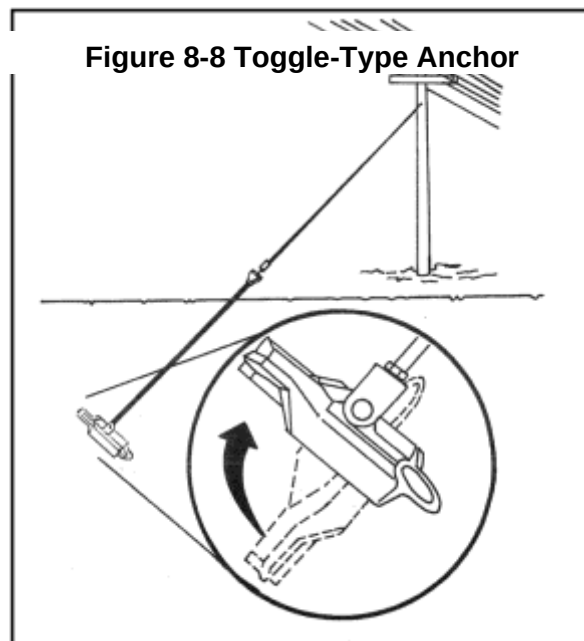
Preliminary soil tests can be performed to measure soil class and soil compaction by measuring the torque required to drive a probe into the soil. The basic test probe consists of a square steel shaft with a helical (drill like) head that is drilled into the soil, and the torque required to drill through the soil is measured. That measured torque value can then be matched with one of the soil classes listed above, depending on the probe design and size of the helical end.

For soils that are known to be corrosive towards rod and anchor plant, there are alternate corrosion-resistant versions of the anchors and insulated guy rods hardware available, as well as operational solutions using insulated guys as per [Chapter 7](#).

## 8.7 Toggle Anchor and Guying System

[Figure 8-8](#) shows a toggle-type anchor used by both communications and power industry companies.

The toggle-type anchor and rod are driven into the earth by a hydraulic or pneumatic hammer. An upward pull on the adapter setting bar rotates the anchor into the set or loadlock position. A gauge on the load locker indicates the pounds per square inch (psi) based on the soil classification required to set the anchor. Anchor models and their load locker gauge reading are shown in [Table 8-6](#). [Figure 8-9](#) shows the various models of toggle anchors.



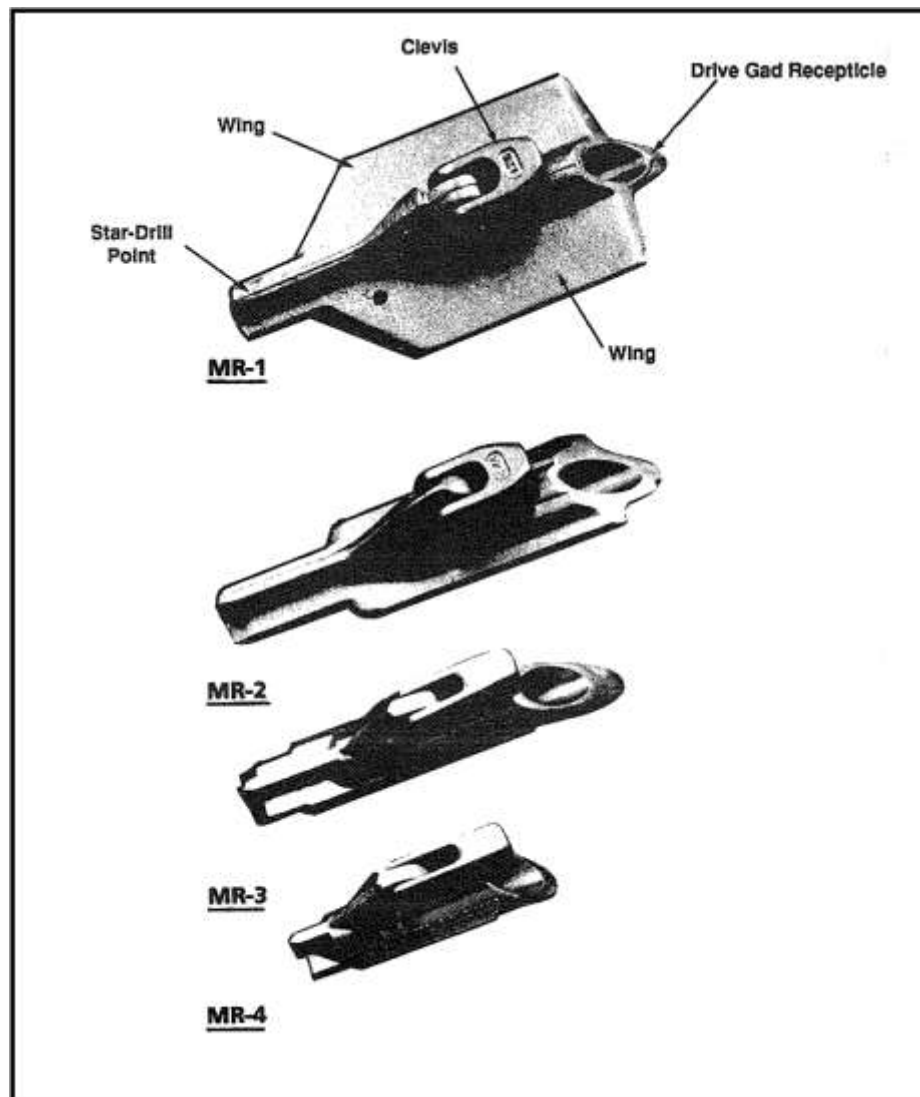
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**Table 8-6 Toggle Anchor Guying Systems**

| <b>Anchor Model #</b> | <b>Soil Class [Note 1]</b> | <b>Load Locker Gauge Reading</b> | <b>Anchor Rod Size and Rating</b> | <b>Maximum Guying Load [Note 2]</b> |
|-----------------------|----------------------------|----------------------------------|-----------------------------------|-------------------------------------|
| MR-1                  | Normal<br>Normal           | 1,600 psi<br>900 psi             | 1 inch (32 M)<br>3/4 inch (18 M)  | Up to 32 M<br>Up to 18 M            |
| MR-2<br>[Note 3]      | Hard<br>Normal             | 1,600 psi<br>900 psi             | 1 inch (32 M)<br>3/4 inch (18 M)  | Up to 32 M<br>Up to 18 M            |
| MR-3                  | Normal                     | 600 psi                          | 5/8 inch (12 M)                   | Up to 12 M                          |
| MR-4<br>[Note 4]      | Hard                       | 600 psi                          | 5/8 inch (12 M)                   | Up to 12 M                          |

- Note:** [1] Soil Class description is based on soil classifications 4 and 5 (normal) and 3 (hard) as described in [Table 8-5](#). The depth of anchor installation, type of soil, and moisture content of the soil will affect the load capacity of the anchor system.
- [2] Multiple guy wire combinations may not exceed the maximum load. The maximum guying load is based on current communications company practices.
- [3] The MR-2 anchor is a dual-purpose anchor. It may be used as a full-size (MR-1) anchor in hard soil conditions or as a lighter capacity anchor in normal soils.
- [4] The MR-4 anchor is a dual-purpose anchor. It may be used as an equivalent to the MR-3 anchor in hard soils or as a lighter capacity anchor in normal soils.

**Figure 8-9 Toggle Anchor Models**

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## 8.8 Adding Eye to Existing Guy Rod

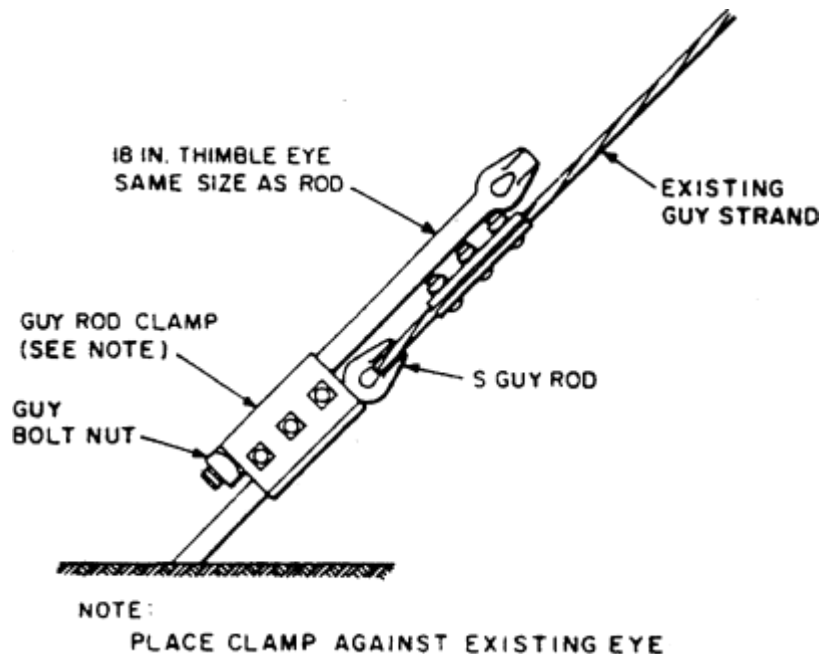
Where spare guying capacity exists in a guy rod, an additional eye may be added. The addition is accomplished by attaching a straight thimble eye bolt to the rod, as shown in [Figure 8-10](#).

**Note:** This procedure requires a loading calculation based on installed plant as well as agreement and concurrence of the owner of the pole and of the guy.

The thimble eye bolt must have the same diameter as the guy rod so that the clamp will close properly.

A 3-bolt guy clamp can be used to install a thimble eye bolt on 1/2-inch guy rods. Use a guy rod clamp for 5/8-inch, 3/4-inch, and 1-inch guy rods. Additional eyes must not be added to the 1-1/4-inch rods.

**Figure 8-10 Adding an Eye on a Guy Rod**



## 8.9 Anchor Strength Verification

The placing guidance on expanding anchors ([Section 8.4](#) and the “not less than 6 inch” advice in [Figure 8-4](#)) is based on the objective of having a secure anchor point for the guy strand.

There is load-locker equipment for manta-ray or toggle anchors as well as other tension testing devices for anchors/rods combinations that are designed to quantitatively measure and verify anchor strength. Screw type anchors are placed with snap-off pins that help confirm that the screw anchor is solidly bonded into the soil.

In lieu of using one of these devices, the traditional approach has been to follow best practices in the earlier sections of this chapter to determine the proper type, size and length of an anchor/rod combination for the soil/rock type in the area. Then, if the appropriate anchor is used and the rod is driven so that around 6-12 inches is left exposed above ground, one can be confident that an adequate point has been established.

If the exposed rod is short (< 6 inch), then concerns may arise about soil contamination of, and abrasive damage to, the strand from contact with rocks and other surface debris that may be around. If the exposed rod portion is long (e.g., >18 inches), then concerns arise that the anchor is not sunk deep enough and may become a trip hazard since the yellow guy marker does not extend below the eye.

However, a sufficiently strong anchoring may still be possible if the exposed length of rod is more than 18+ inches since the soil type may vary considerably as one goes deeper underground. For example, one may find a layer of hard shale or sandstone (soil class 3) underneath a layer of clay (soil class 5-6), and that shale layer will provide an excellent anchoring point without needing to drive the rod as deep as would be needed for clay.

Without such precise knowledge of soil/rock changes in the underground, one relies on either (a) driving the rod sufficiently deep following the 6-18 inch guideline, or (b) using a load-lock, torque pins, or tension testing device to verify the anchor strength. The devices may be driven by pneumatic or hydraulic power sources and have a rated pressure or tension reading for the soil type and maximum guy load expected (e.g., see load-lock ratings in [Table 8-6](#)). These load-lock and tension devices test the anchor by pulling up and verifying full and solid engagement with the surrounding soil/rock.

For guy anchors with the single or twin helical screws ([Section 8.5](#)) that are drilled into place, the installation procedure includes a drive mechanism with pins that snap off at certain tensions. The assumption is that an anchor that requires sufficiently high torque to place is providing an adequate anchor strength for the guy.



## 8.10 Removal of Anchors and Guys

The removal or replacement of guys or anchors requires due care and attention because the work can involve strands under tension and guy wires moving in the vicinity of power lines.

Apart from the general safety guidance found in [Chapter 2](#) covering work aloft on the pole and in the vicinity of a power plant, there are several specific additional items relevant during the removal of anchors or guys, including the following:

- Never cut guy strand while it is under tension - use chain hoist or other support method/means to relieve strain before cutting guy strand.
- Where guys to be removed extend through working circuits, added care is required to prevent contact with these lines and loss of service. Such care involves taking precautionary measures to help ensure loose ends of guys from springing back and causing injury to the worker (skin abrasions or puncture damage) or flipping up and contacting power lines above. The guy ends should be secured to prevent injury or contact with power facilities (power phase conductors, ground/neutral wires or power guys).
- For guys that may come into contact with power lines of greater than 5 KV-to- ground, it is preferable for the guy removal to be completed by the power utility.

In general, guy rods and anchors are abandoned in place by digging around the rod and down for 12-18 inches to permit the use of a hacksaw to cut the rod off 6-12 inches below the surface. For several anchors such as the wrench, screw and swamp type anchors, the rod/anchor can be backed out removed using a pipe wrench and turning the rod/anchor in a counterclockwise direction until the complete unit (rod

+ anchor) rod is extracted or the rod/pipe is unscrewed from the base. Whichever method is used, the resulting hole shall be back-filled and tamped firmly down to help prevent settling of the ground. Holes in pavement and broken pavement caused as the result of rod/anchor extraction should be patched as soon as practical.

### 8.11 Normative and Informative References Related to Anchors

1. Telcordia (Bellcore) Recommended Practice BR-621-415-220, *Toggle Anchor Guying System*.
2. Bell System Practice 621-415-011, Patent Guy Anchors – General.
3. Bell System Practice 621-415-200, Patent Guy Anchors – Expanding Anchors.
4. Bell
5. Practice 621-415-204, System Practice 621-415-201, Screw Type Anchors.
6. Bell System Practice 621-415-202, Patent Guy Anchors – Swamp Anchors.
7. Bell System Practice 621-415-203, Patent Guy Anchors – Plate Anchors.
8. Bell System C Guy Anchors - Power Installation.
9. Bell System Practice 621-415-211, Nonpatent Anchors – Plank Anchors.
10. Bell System Practice 621-415-215, Rock Anchors – Placing.
11. Bell System Practice 621-420-241, Removal of Guys and Anchors.

## 9 Suspension Strand - False Dead-Ending and Slack Span Construction

### 9.1 General

This section covers the methods and materials used for making false dead-ends on suspension strand and self-supporting cable with strandvises and guy clamps. A wrap-type device manufactured especially for making false dead-ends is called a “false dead-end.”

False dead-ends are required at strand diminishing points and where there is a large difference in strand tension such as the following:

- Where slack span construction is used
- Where a lead changes from short-span to long-span construction
- Where a long span falls between adjacent short spans.

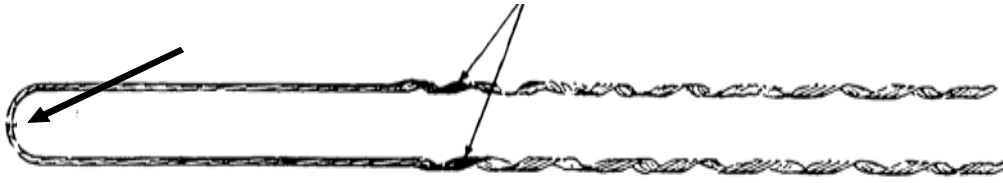
The objective of these false-dead end configurations are to help ensure that no unbalanced loads are placed on the pole.

The hardware shown in the figures in this section is representative. Local field conditions must be considered in choosing acceptable substitutes for the hardware shown. For example, the false dead-end strandvise is not recommended for use on corrosion-resistant strand or in seacoast (marine) locations where extreme conditions of exposure to salt spray or salt fog may be encountered (see Sections 9.3 and 5.13).

**! CAUTION !** Slack span construction, as defined in this section, *does not cover the requirements for construction of aerial plant that creates an unbalanced load on pole lines. The placing of attachments, cable, and hardware at various angles and span lengths on non-guyed poles requires the approval of the pole owner (licensor) and is subject to their design requirements prior to installation.*

### 9.2 Wrap-Type False Dead-End

A wrap-type false dead-end (Figure 9-1) can be used to construct false dead-ends on Class A or Class C galvanized strand or the support strand of self-supporting cable.

**Figure 9-1 Wrap-Type False Dead-End**

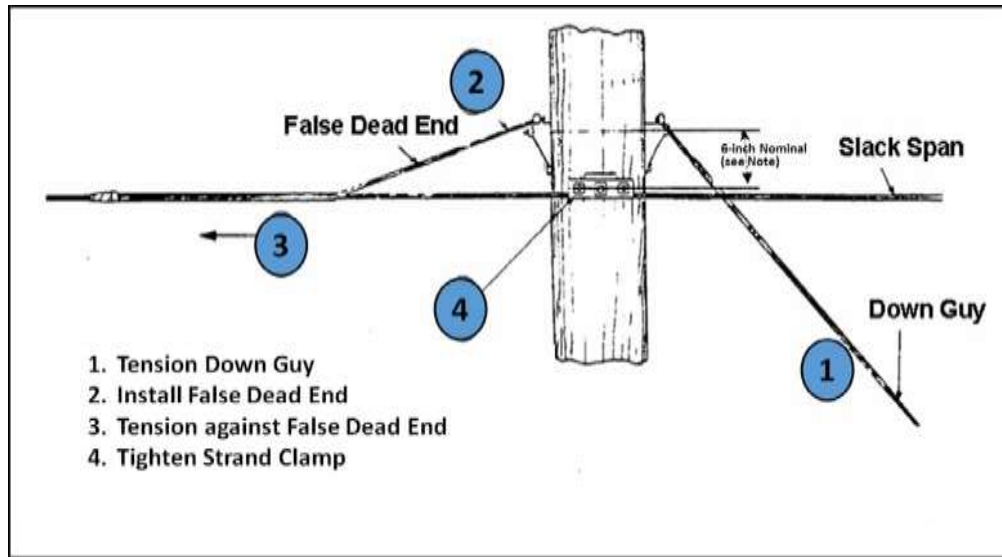
False dead-ends are available in sizes corresponding to suspension strand sizes. Each false dead-end is color-coded with two paint markings: color mark “A” at the starting or crossover point, and color mark “B” at the base of the loop. See [Table 9-1](#).

**Table 9-1 False Dead-End for Galvanized Steel Strand**

| Strand Size | Strand Diameter | Color Code |
|-------------|-----------------|------------|
| 6 M         | 5/16-inch       | Black      |
| 6.6 M       | 1/4-inch        | Yellow     |
| 10 M        | 3/8-inch        | Orange     |
| 16 M        | 7/16-inch       | Green      |
| 25 M        | 1/2-inch        | Blue       |

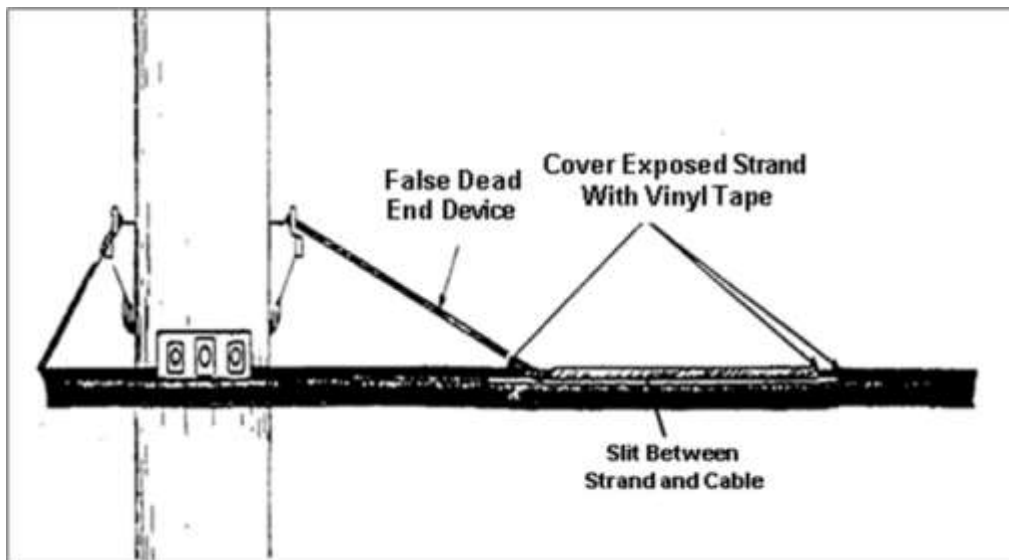
**! CAUTION !** *The false dead-end must not be reused after its initial installation.*

[Figure 9-2](#) shows a wrap-type dead-end installation where slack span construction is used and also outlines the tensioning procedures. Slack spans should not exceed 100 feet and terminate at an attachment on a building or to an un-guyed pole where the load is only from the weight of cable and strand.

**Figure 9-2 Wrap-Type False Dead-End Slack Span**

**Note:** Although a 4-inch separation has been used in the past, one should endeavor to have a nominal 6-inch separation for increased reliability and less chance of compromising the pole integrity with too many holes drilled too close together over several reconfigurations of facilities on congested poles.

Figure 9-3 shows a wrap-type dead-end installation on the support strand of self-supporting cable.

**Figure 9-3 Wrap-Type False Dead-End Installed on Self-Supporting Cable**

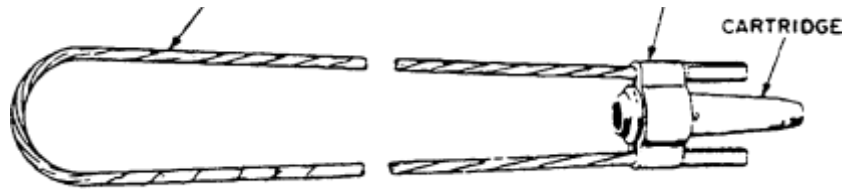
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### 9.3 False Dead-End Strandvice

The false dead-end strandvice (Figure 9-4) consists of a cartridge, a yoke, and a strand-type bail. Because of its construction, the strandvice cannot be used at locations where the strand is continuous.

**Figure 9-4 False Dead-End Strandvice**



The strandvice cartridge is a tapered shell containing a spring-loaded 3-jaw chuck for gripping the strand. A pilot cup at the outer end of the chuck prevents spreading of the strand wires and facilitates insertion of the strand into the cartridge.

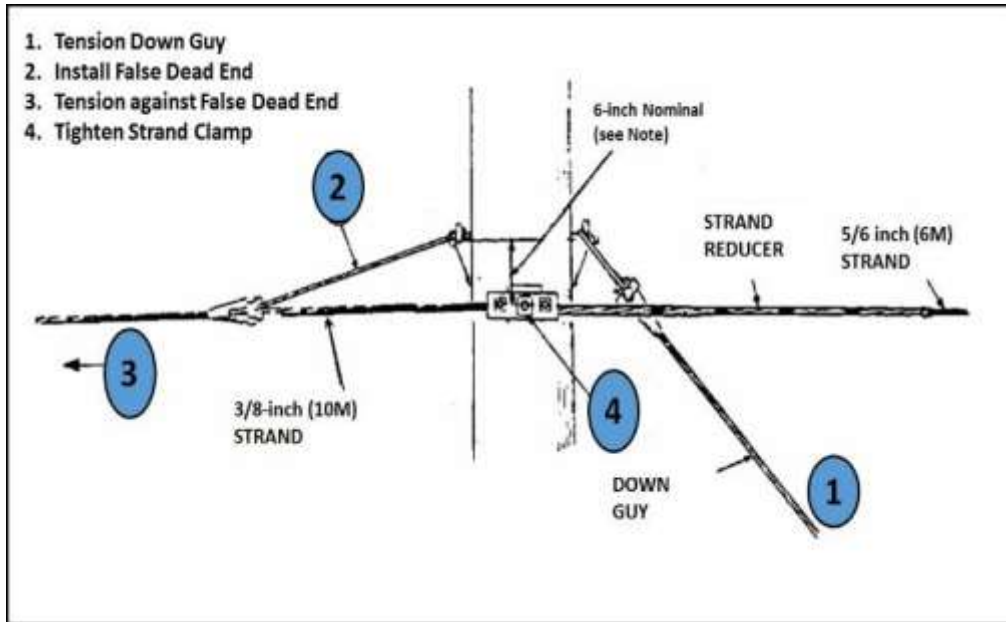
The cartridge for the strandvice is available as a replacement part when the bail and yoke are reusable. The bail and yoke may be used with a new cartridge. *Do not reuse the cartridge.*

Strandvices are available to fit all sizes of strand.

A false dead-end strandvice is not to be used on corrosion-resistant (CR) strand.

**Note:** It is not advisable to use false dead-end strandvices in seacoast locations where salt-spray and salt-fog conditions may be encountered.

Figure 9-5 shows an installation of a false dead-end strandvice and shows the procedure for tensioning at the point where the strand size changes.

**Figure 9-5 False Dead-End Strand Installed at Strand Diminishing Point**

**Note:** Use the same step sequence (1-2-3-4) as in [Figure 9-2](#).

**Note:** Although a 4-inch separation has been used in the past, one should endeavor to have a nominal 6-inch separation for increased reliability and less chance of compromising the pole integrity with too many holes drilled too close together over several reconfigurations of facilities on congested poles.

The strand reducer shown in [Figure 9-5](#) is a wrap design where the two strand different sizes are wrapped together to form a solid bonded splice. In general, this strand reducer should not be placed through the strand clamp (or hanger) since the resulting compression of the strand reducer may damage or weaken the physical strength of the reducer.

#### 9.4 Guy Clamp False Dead-End

False dead-ends using guy clamps are constructed as shown in [Figure 9-6](#), [Figure 9-7](#), and [Figure 9-8](#). The method shown in [Figure 9-6](#) can be used at slack span locations and where the strand size changes.

**Figure 9-6 False Dead-End Using Guy Clamp Method on 6.6 M and 6 M Strand Supported by a Cable Strand Connector**

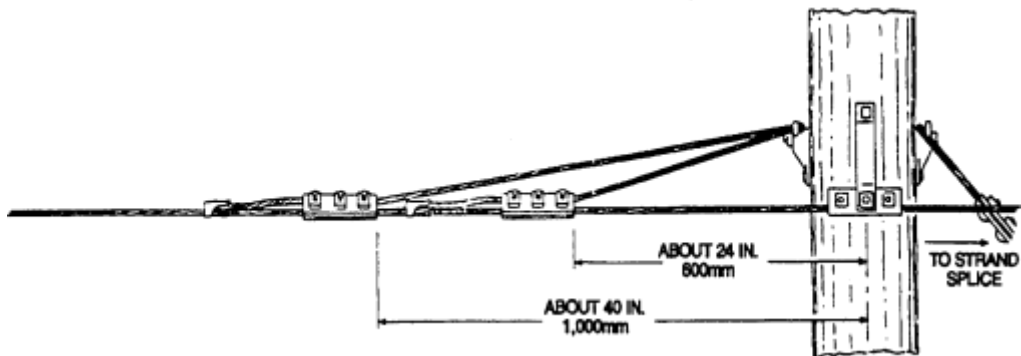
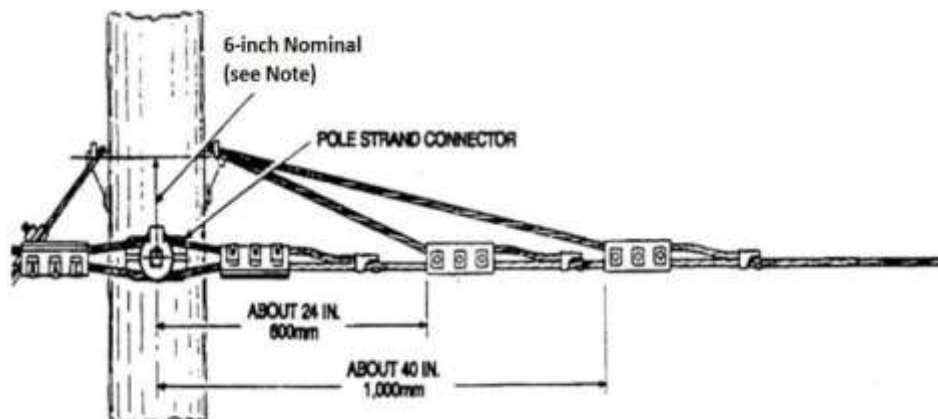


Figure 9-7 shows an arrangement where the strand size changes and a pole strand connector is used to join the strands.

**Figure 9-7 False Dead-End Using Guy Clamp Method on 6.6 M and 6 M Strand Supported by a Pole Strand Connector**

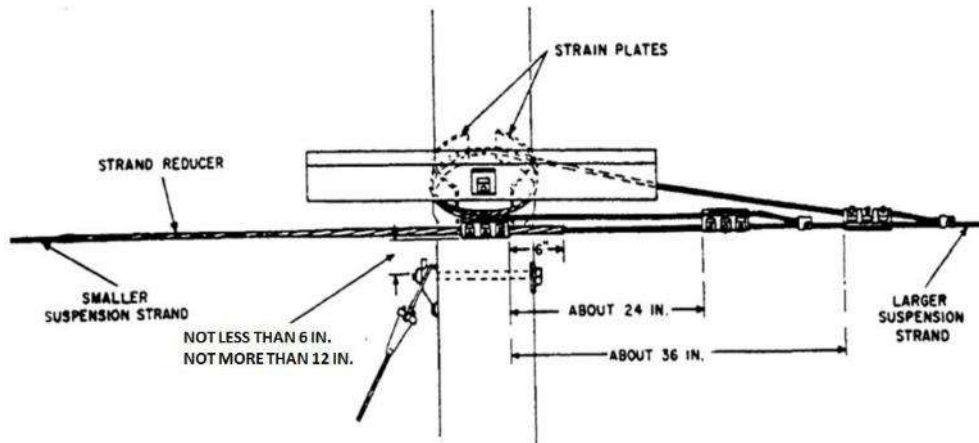


**Note:** Although a 4-inch separation has been used in the past, one should endeavor to have a nominal 6-inch separation for increased reliability and less chance of compromising the pole integrity with too many holes drilled too close together over several reconfigurations of facilities on congested poles.



Figure 9-8 shows an arrangement where a false dead-end is constructed at a pole with a guard arm.

**Figure 9-8 False Dead-End Using Guy Clamp Method at Arm Location**



## 9.5 Strandwise and Guy Clamp False Dead-End

False dead-ends can be constructed by using a combination of guy clamps and a strandwise. Figure 9-9 shows a conventional installation. Figure 9-10 shows an installation where the suspension strand is attached to a cable extension arm approved by the communications company.

**Figure 9-9 False Dead-End Using Strandwise and Guy Clamps**

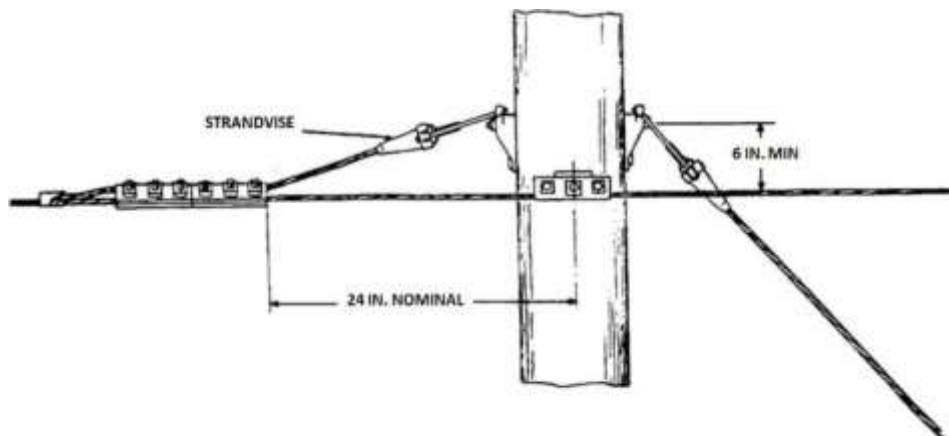
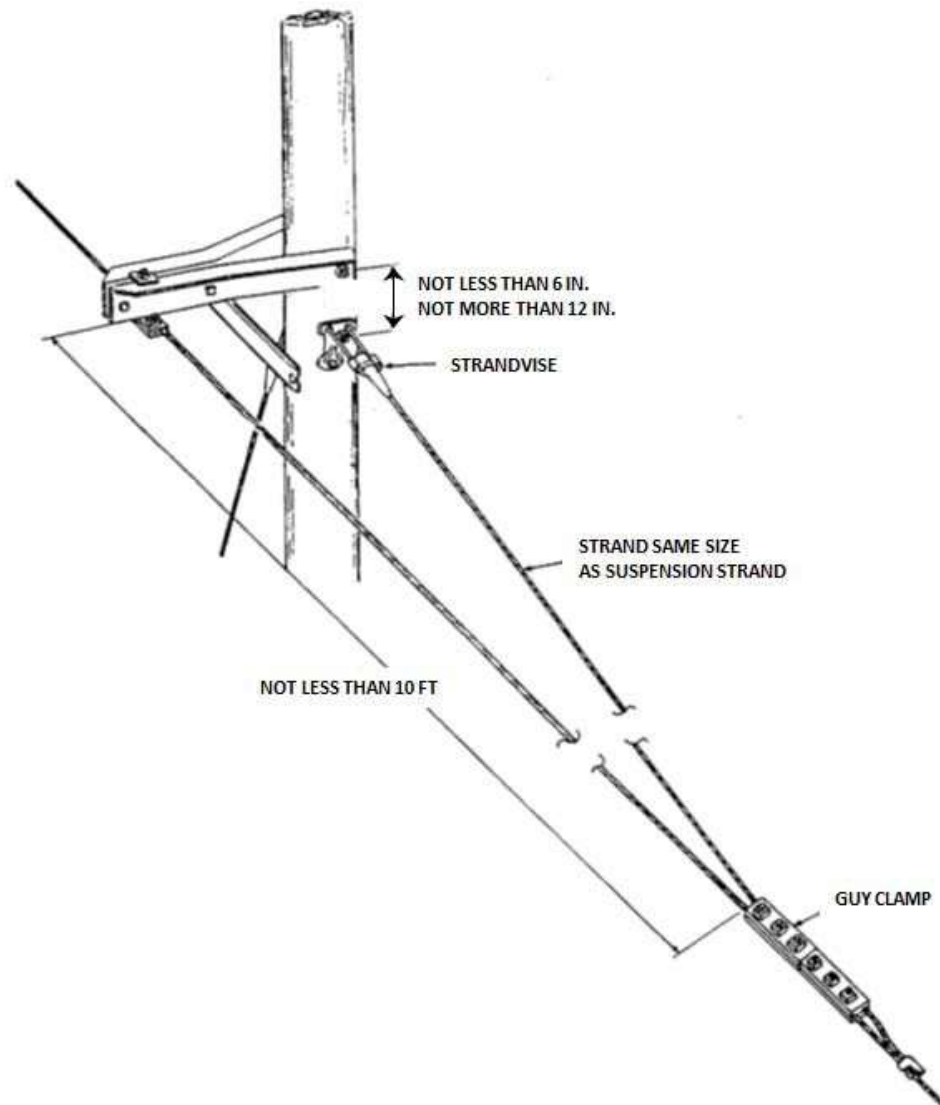


**Figure 9-10 False Dead-End Using Guy Clamps and Strandvise at Cable Extension Arm Location**



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## 9.6 Strand String Tension

**! CAUTION !** It is *dangerous to ride a slack span* unless a temporary guy can be placed at the dead-end. Where a temporary guy cannot be placed, use an *extension ladder, aerial lift truck, etc., when working in the slack span.*

Table 9-2 lists optional strand stringing tensions for various strand sizes when attached to poles. Stringing tensions, when attached to building attachments, must be reduced. Use minimum stringing tension if the required tension is not specified by the plant engineer.

**Table 9-2 Optional Stringing Tensions for Slack Spans**

| Ambient Temperature | Approximate Strand Stringing Tensions in Pounds |                 |                 |                  |
|---------------------|-------------------------------------------------|-----------------|-----------------|------------------|
|                     |                                                 | 6 M Strand Size | 8 M Strand Size | 10 M Strand Size |
| 100°F or 38°C       | Min.                                            | 175             | 175             | 175              |
|                     | Max.                                            | 500             | 300             | 500              |
| 60°F or 17°C        | Min.                                            | 300             | 300             | 300              |
|                     | Max.                                            | 800             | 500             | 800              |
| 20°F or -7°C        | Min.                                            | 425             | 425             | 425              |
|                     | Max.                                            | 1100            | 700             | 1100             |

If existing joint-use poles are too congested for planned wireless attachments, some users are erecting wireless-only unguyed poles where antennas and associated equipment mounted on the pole are served powering and backhaul communications cables across slack span strand to the main pole line.

The chief concern is that under normal stringing tensions the unbalanced load on an unguyed dead-end pole (i.e., slack span) will exceed the pole's capability to remain erect. Those unbalanced loads on the dead-end pole can come from the combination of cable and messenger plus any contributions from possible wind and ice loads given the environment and expected weather that may require application of safety factors to the pole loading calculations.

The traditional solutions to these concerns include -

1. Use an anchor guy, a pole-to-pole guy or a pole-to-stub guy whenever possible instead of using a slack span.
2. Limit the tension in the slack span to the dead-end pole to less-than-normal stringing tensions.
3. Limit slack spans to less than 100 feet. –

**Note:** This 100-foot maximum was based on the multipair metallic cable weight and the allowable pole strength under applicable wind and ice loads on the cable. Although more modern fiber and coaxial cables serving sites may have lighter weight per foot, one still needs to consider the total weight in the span including any fiber cable loops, messenger strands and other equipment mounted on the strand, as well as any other load on the dead-pole from facilities mounted on that pole and drops from that pole.

4. Set the dead-end pole on the slack span to greater (1-2 feet) than standard depths to limit tilting of the pole specified in Table 13-5 of Section 13.7.

The fundamental design considerations for building a slack span include:

1. Load - Size of cable and weight/foot, and size of any strand mounted equipment in span
2. Size of pole (pole Class and size) and height of attachment on pole
3. Applicable Loading Factors - Construction Grade (NESC Rule 242) for the pole line.
  - a. NESC Loading area (Heavy, Medium, Light) needs to be considered when determining the maximum allowable tension for a given pole.
  - b. Possible maximum sag required - need to take into consideration any road clearance requirements, etc..
4. Attachment strength and configuration - The attachment to a pole or building plays an important role in strength loading.
  - a. The pull on the dead-end pole or building attachment may not be direct in line with support equipment - it may place a significant sideways load onto the attachment point which may be less strong in that direction.

Table 9-3 lists the approximate sag that can be expected at 60°F (17°C) for the typical slack spans. The amount of sag must be added to the required above-ground clearance to obtain the correct height of attachment.

**Table 9-3 Approximate Slack Span Sags and Tensions for 100-Foot Spans at 60°F (17°C)**

| Strand Size | Maximum Cable Weight |      | Initial Stringing Tension |               |         |               |         |               |
|-------------|----------------------|------|---------------------------|---------------|---------|---------------|---------|---------------|
|             |                      |      | 300 lbs                   |               | 500 lbs |               | 800 lbs |               |
|             |                      |      | Sag                       | Final Tension | Sag     | Final Tension | Sag     | Final Tension |
|             | lbs/ft               | kg/m | in                        | lbs           | in      | lbs           | in      | lbs           |
| 6 M         | 3.0                  | 4.2  | 27                        | 1700          | 25      | 1910          | 23      | 2060          |
| 10 M        | 5.0                  | 7.0  | 31                        | 2560          | 29      | 2740          | 27      | 2900          |

Longer slack spans than 100 feet are permitted, but only with limitations on

- Cable weights shall be less than 2lb/ft
- 6M or 10 M strands are used
- Slack span lengths shall be less than 150 feet
- Initial stringing tensions be kept between 350 and 450 lbs

Such limitations will help into help keep

- initial sags below 30 inches (i.e., between 15 to 30 inches)
- final sags (after storm loading) below 36 inches (i.e., between 25-36 inches)
- final tensions (after storm loadings) below ~1600lb for 6M strand and ~1750lb for 10 M strand
- tensions during storm below ~2500lb for 6M strand and ~3000lb for 10 M strand

For these longer slack span length, the larger sags and tensions after storms is a concern for slack spans which can result in ground clearance problems and pulls on poles; in addition to possible larger unwanted motion under winds.

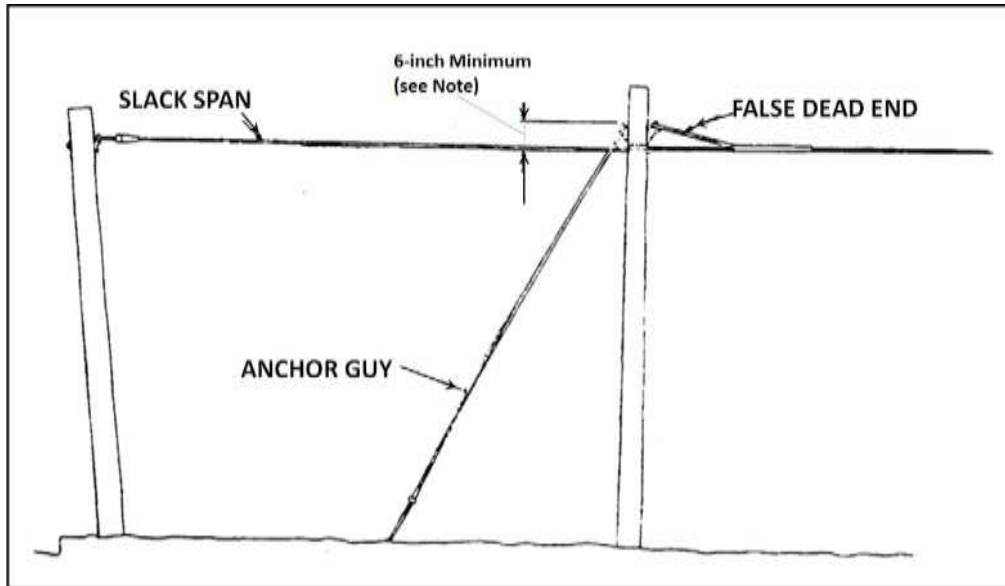
## 9.7 Constructing the Slack Span

The dead-end pole size and the depth of set will be shown on the work print. Set the pole with rake of 1 foot or the width of one pole, in the direction away from the slack span.

Where possible, install an anchor guy on the second pole. For guying

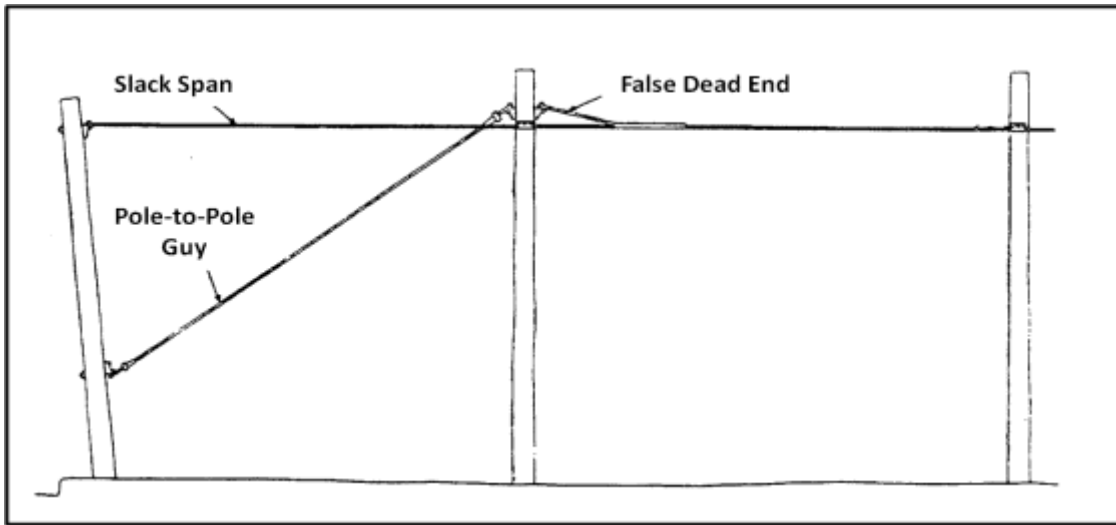
purposes, consider the second pole as the strand dead-end pole and determine the size of the guy in the usual manner. Install the guy for placement of a false dead-end in accordance with [Figure 9-11](#).

**Figure 9-11 Anchor Guy Installed for Slack Span Construction**

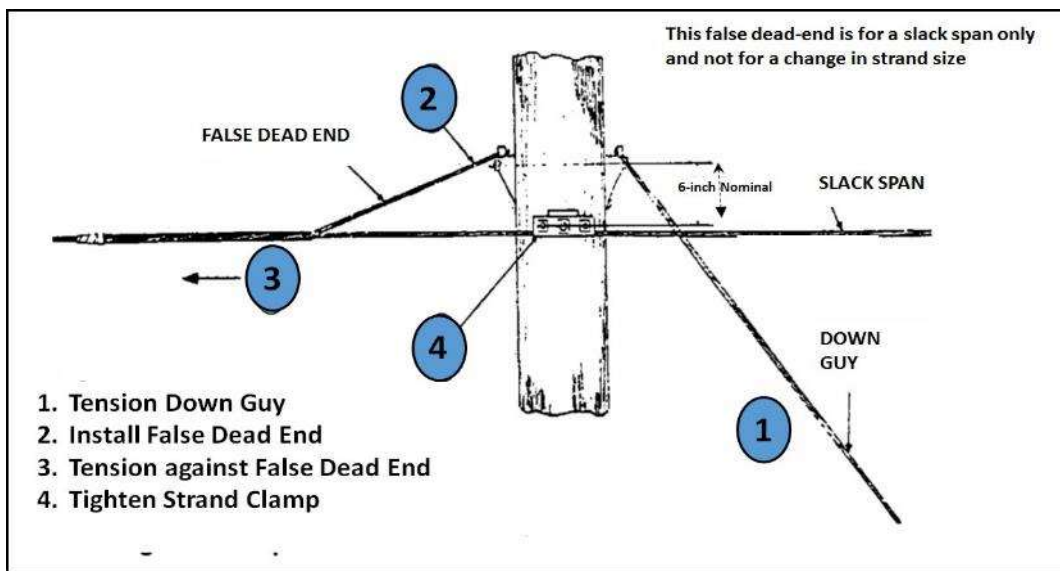


**Note:** Although a 4-inch separation has been used in the past, one should endeavor to have a nominal 6-inch separation for increased reliability and less chance of compromising the pole integrity with too many holes drilled too close together over several reconfigurations of facilities on congested poles.

Where an anchor guy cannot be placed on the second pole, install pole-to-pole guys between the dead-end pole and the second pole, and between the second and the third pole, as shown in [Figure 9-12](#).

**Figure 9-12 Pole-to-Pole Guys Installed for Slack Span Construction**

Place the strand in the normal manner, dead-ending the strand on the slack span end pole and supporting it in the cable-suspension clamps on the other poles in preparation for final testing. A typical installation of a false dead-end and the proper sequence for tensioning strand at a slack span is shown in [Figure 9-13](#).

**Figure 9-13 False Dead-End at Slack Span Location (No Change in Strand Size)**

## 10 Bonding and Grounding for Aerial Plant

This chapter summarizes the methods used to bond and ground the elements of communications plant and associated attachment support hardware in the aerial plant collectively referred to below as “plant elements.”

[Chapter 25](#) contains further background information as well as details for grounding and intersystem bonding requirements at customer locations and building entrances where the installation shall be in accordance with the NEC, the NESC, and any applicable local building/electrical codes. The reader can also refer to:

- [Chapter 14](#) for discussions on bonding and grounding for pole mounted equipment
- [Chapter 15](#) for guidance on bonding/grounding of wireless facilities
- [Chapters 17 and 20](#) for bonding and grounding procedures in buried and underground plant facilities.

### 10.1 Background

Bonding and grounding of supporting hardware such as the suspension strand reduces the possibility of electrical shock and minimizes plant damage if the strand accidentally contacts or is contacted by energized power wires.

It is useful to review some basic terminology for this and subsequent sections related to bonding and grounding. The terms bonding and grounding, while too often used interchangeably, are not the same and do not produce the same end results.

- Grounding eliminates potential differences between the plant element and earth.
- Bonding eliminates potential differences between two or more plant elements.
- Bonding and grounding are effectual only when the plant elements involved are conductive.
- Bonding two plant elements does not eliminate a potential difference from either one to earth, unless one of them possesses an adequate path to earth.

The need to bond communications plant occurs when it is categorized as EXPOSED. There are four conditions, any one of which can place the communications plant element into that exposed category:

#### 1. Lightning

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2. If contact with power in excess of 300 V to ground is possible
3. If proximity of power facilities can induce voltages in excess of 300 V to ground on the communications plant
4. If ground potential rises in excess of 300 V exist.

Factoring out the lightning-induced phenomenon over which one can exercise little if any control, then the primary reason communications companies bond components in the OSP is because of the presence of power supply facilities.

Additional significant expenses are incurred in providing protectors at each customer premise to provide them with protection from lightning and contact with the communications plant that has been energized by a power fault.

Many years ago it became obvious that all parties, including the customer, could profit measurably by sharing poles and trenches, not to mention the environmental benefits. Obviously, no such arrangement can be successful unless a positive and cooperative attitude is shared by all parties. This need for cooperation between all communications and supply utility companies is intrinsic for the NESC to achieve its safety objective.

Hence, the bonding requirements are not to be viewed as a one-way street to protect only communications workers, but as a necessary and required union of two exposed facilities that are owned by different utilities in order to comply with rules that are common to both. The interdependence of power and communications networks is discussed further in Chapter 1 and Appendix C.

It is important that the communications provider and the power utility work together to help ensure the protection of the public, their employees and the network plant elements. The communications plant is intended to be an integral part of the grounding system used on joint-use structures to achieve that protection.

### 10.1.1 Changes in 2023 Edition of NESC

#### Intersystem Bonding –

NESC Rule 097G covers intersystem bonding between the grounds of the communications and power systems in the aerial plant of the distribution network. Rule 097 was reformatted for clarity in the 2017 Edition and reaffirmed for the 2023 edition with new guidance added to Rule 384C as a note covering the connections to the vertical pole ground. Below are relevant excerpts from the NESC code:

**097G. Bonding of communications systems to electric supply systems**

*Where both electric supply systems and communications systems are grounded on a joint use structure, and a single grounding conductor is present, the grounding conductor shall be used for connected to both systems. Where separate supply and communications grounding conductors are used, they shall be bonded together.*

*EXCEPTION 1: Where separation is required by Rule 097A.*

*EXCEPTION 2: Where the electric supply utility is maintaining isolation between primary and secondary neutrals, the communications system ground shall be connected only to the primary grounding conductor. if it complies with the requirements of Rule 097C.*

.....

**384-C.** Bonding should be provided between all aboveground metallic supply and communications enclosures that are separated by a distance of 1.8 m (6 ft) or less. For the purpose of this rule, pole grounds are not required to be bonded to the communications enclosure

**“Note:** This rule does not prohibit bonding communications metallic enclosures to supply pole grounds, providing all parties agree“

The additional note added to 384C requires an explicit agreement because of the understanding that there are circumstances where bonding between the vertical pole ground of the power circuits and an adjacent communications pedestal can create a more hazardous situation than not bonding. One does not wish to connect

the two grounding systems together if the result will be the more ready introduction of foreign voltages from the power circuits or power faults into communications shields and circuits.

**Note:** The approach in NESC Rule 384C is based on a 2009 NEETRAC Report Project 09-043 Report, *Connection of Communications Pedestal ground with Distribution Pole Ground - An Investigation Using WinIGS Program.*

NESC Rule 097 has seven inter-connected (A through G) subsections with implicit and explicit links to other NESC Rules, including 096, 224, 344, 354, and 384, that are relevant to intersystem bonds.

- Rule 097A requires separate grounding conductors except as permitted by 097B, providing 097C (4 grounds/mile) is met. This correctly keeps separate the grounds that come from lightning surge arrestors,

lightning rods and other conductors which can experience high currents or voltages.

- Rule 097B – permits bonding between various grounds where a Multi-Grounded Neutral (MGN) system is being used and providing Rule 097C (i.e., 4 grounds/ mile) is met.
- Rule 097C – contains the 4 grounds/mile criteria that helps define an effective ground
- Rule 097G requires a single grounding conductor on structures except as required by Rule 097A.

The combination of Rules 097G, 097B and 097C is the basis for the practice of bonding communications ground to the vertical pole supply ground in MGN systems with a 6 AWG conductor and an approved connector. It is highly desirable to maintain this practice with an intersystem bond between the power and communications grounds as a first choice.

The exceptions within Rule 097G are included to distinguish between situations where bonding should be done, for example to the MGN vertical ground in cases of MGN power systems as opposed to situations where it is to be avoided, such as from surge arrestors, lightning rods, or in cases where ungrounded or single grounded power systems exist.

### 10.1.2 Basic Precautions

Safe work practices apply to every aspect of a technician's job functions. In the context of grounding and bonding in aerial plant, the following practices apply in situations when a technician is working around poles or in the aerial plant:

- Points at which a technician is either intending to touch or may accidentally come into contact with should be tested for foreign or hazardous voltages prior to beginning the work; that includes the pole and cable/strand plant.
- Prior to working in the communications plant or closures, technicians must test all metallic pedestals/boxes/closures and sheath grounds with a hazardous voltage test set.
- Street lighting fixtures and traffic control boxes may often be found close to the communications space on the pole (see [Section 3.3](#), [Table 3-1](#) and [Figure 3-5](#)). If close to the communications plant, these brackets and fixtures should be grounded as required by NESC Rule 238. However, the technician cannot rely on this rule, particularly with older plant, and needs to test such brackets and fixtures for voltage prior to working near them.
- Never disconnect another utility's (i.e., power or cable company) ground connection.
- When working in aerial plant, the technician should inspect the vertical

ground wire, grounding clamps and any associated wires/connectors looking for any

- Broken or disconnected wires
- Loose connections
- Defective, damaged, or corroded hardware
- Grounding and bonding conductors that have kinks or sharp bends.

Any of the above conditions found in the communications plant shall be repaired or components replaced to help ensure an effective bond and ground connection.

## 10.2 General

Grounding the suspension strand accomplishes the following:

- Limits the voltage on the strand if it accidentally contacts energized power conductors
- De-energizes the power circuit quickly after an accidental contact by causing the operation of circuit breakers or fuses
- Drains off induced voltages that may be on the strand.

***The company responsible for bonding the strands will be specified by the communications company in compliance with the License (Pole Owner) Agreement (see Chapter 26 on Joint-Use Agreements) .***

The required intervals for bonding the support strand to the power system MGN depend on the power system voltage. When plant is jointly placed with power system voltages ranging from 300 V to 34.6 kV rms to ground (i.e., 69 kV phase-to-phase systems), bonds are required at both ends of the section and at 1/4-mile (400 m) intervals.

**Note:** The NESC language of Rule 92(C)(1) requires “...*four (4) connections in each mile...*”, which could be strictly met with connections every 1/3 mile. The traditional interval of every 1/4 mile or every 1,000 feet noted above has been used to accommodate situations where a connection could not be made at the desired point for very practical reasons such as no pole, no ready access to strand/messenger, etc.

For voltages greater than 34.6 kV rms to ground, the Inductive Coordination and Electrical Protection (ICEP) engineer (also can be called the “*Protection Engineer*”) must be consulted.

For power systems where voltages are between 15 kV and 34.6 kV phase-to-ground, it is desirable to have protection provided through having an umbrella of lower voltage distribution lines between the high voltage transmission line and the communications lines.

---

**! CAUTION !** Joint use is not recommended and should be avoided under power lines where voltages exceeding 69 kV phase-to-phase or 86kV phase-to-ground exist.

---

**Bonding** is electrically connecting two or more pieces of communications hardware or connecting communications hardware to hardware belonging to another utility to maintain a common electrical potential. Bonding conductors must be of sufficient gauge to carry anticipated current in the event of a power contact.

**Grounding** is electrically connecting communications hardware to an **electrical ground rod** or **grounding system**. An acceptable ground for this electrical purpose can be a power system MGN, a grounded neutral of a secondary power system with at least three customer services connected, a metallic water system, an extensive underground or buried cable system, or a specially constructed grounding network.

An **electrical ground** is a low-impedance ground, such as the power MGN, that is low enough to operate protective equipment. Electrical connection to a low- resistance or low-impedance ground permits electric current to discharge to ground without the buildup of hazardous voltages on the communications plant in case of electrical contact.

**Note:** In NESC and other safety codes, the ground defined here is denoted as an “effective electrical ground.”

**Electrical connections of aerial plant to anchor rods, ground rods, butt plates, butt wraps, or down guys are not considered adequate electrical grounds.** These connections are high-impedance grounds that do not provide optimum protection against hazardous voltages resulting from power wires coming in contact with communications plant, or against lightning voltages.

For optimum protection, the power system MGN must be the first choice for grounding, followed by the other alternatives outlined above.

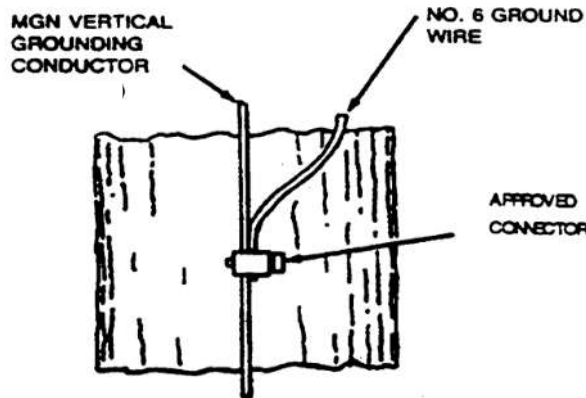
All bonding and grounding connectors and clamps must be rated for outside use and properly sized to accept the wire and strand size involved. (A No. 6 AWG copper wire shall be used for all connections.)

Where non-joint aerial plant is exposed to lightning and inductive power influences, and there is no access to the power MGN system, driven ground rods and un- insulated anchor guys may be used for grounding.

### 10.3 Methods of Bonding and Grounding

The connection to a vertical grounding conductor of a power system MGN is made in the communications space on a pole by using an approved connector determined by the power supply company chosen with the communications company (Figure 10-1).

**Figure 10-1 Connecting to a Vertical Grounding Conductor**

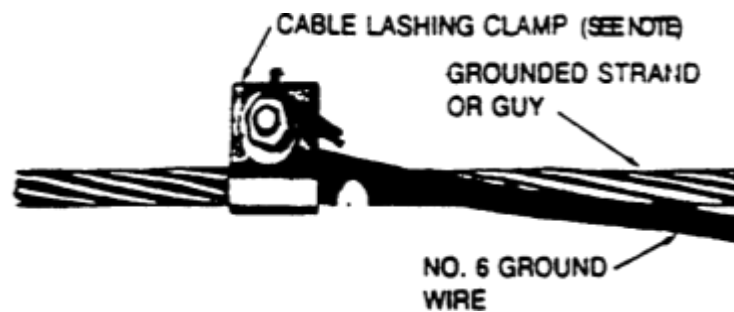


The term “approved connector” in this context refers to connectors selected through the purchasing and product procurement organization(s) of the communications company. This selection process should include performance and materials product testing to help ensure that the connector will perform adequately over the expected design lifetime of the connector in the outside plant environment where it shall be used and under the expected currents and voltages.

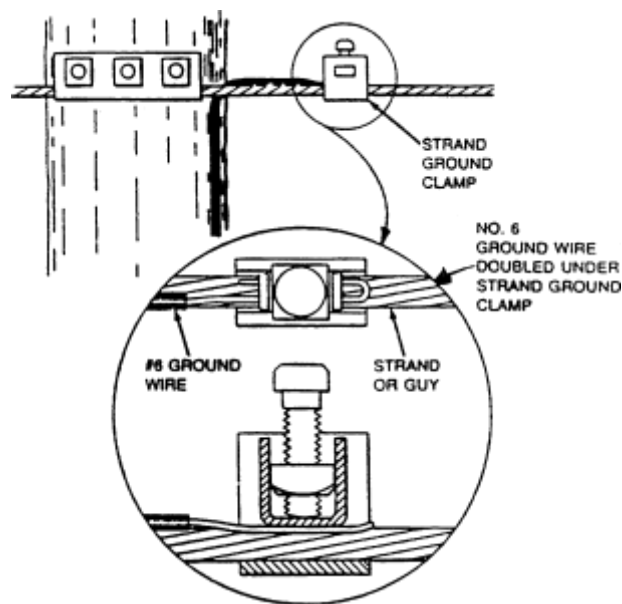
Bonding communications company hardware to power company fixtures shall be done only when authorized or permitted by the power company, and all connections shall be made according to locally established methods and procedures.

If permission to bond to the MGN is denied, then contact the ICEP or protection engineer for guidance. It may be necessary or desirable to place a ground bed (e.g., a series of three interconnected ground rods at the base of the pole, see [Section 10.5](#)) and bond the communications plant to that ground bed. Such ground beds may be necessary for the safety of workers and/or to help maintain the reliability of equipment.

The connection to a guy or strand (except 25 M) is made with a cable-lashing clamp or strand ground clamp, or other approved connector. For 25 M strand, use only the strand ground clamp. See [Figure 10-2](#) and [Figure 10-3](#).

**Figure 10-2 Connecting to a Guy or Strand with a Cable-Lashing Clamp**

**Note:** Cable-lashing clamps are not recommended for bonding and grounding connections in a corrosive environment.

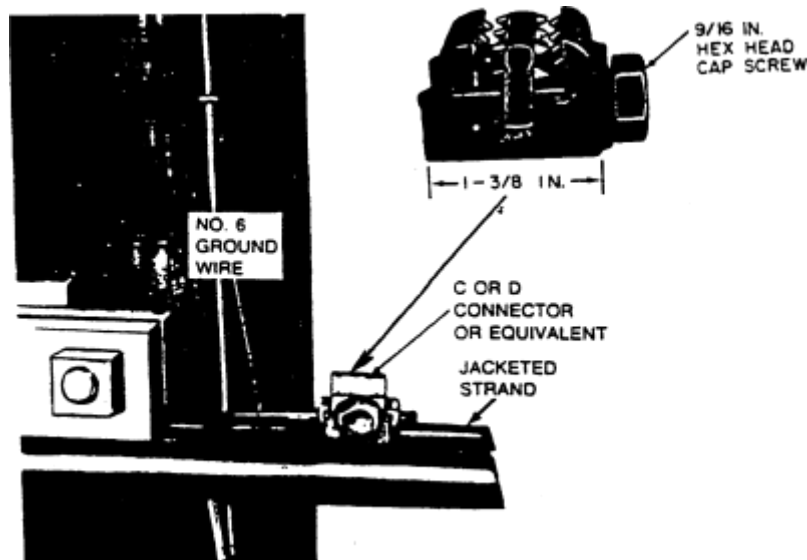
**Figure 10-3 Connecting to a Guy or Strand with a Strand Ground Clamp**

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The connection to a jacketed (self-supporting cable) strand is made with C or D connectors or equivalent, as shown in [Figure 10-4](#).

**Figure 10-4 Connecting to Jacketed Strand**

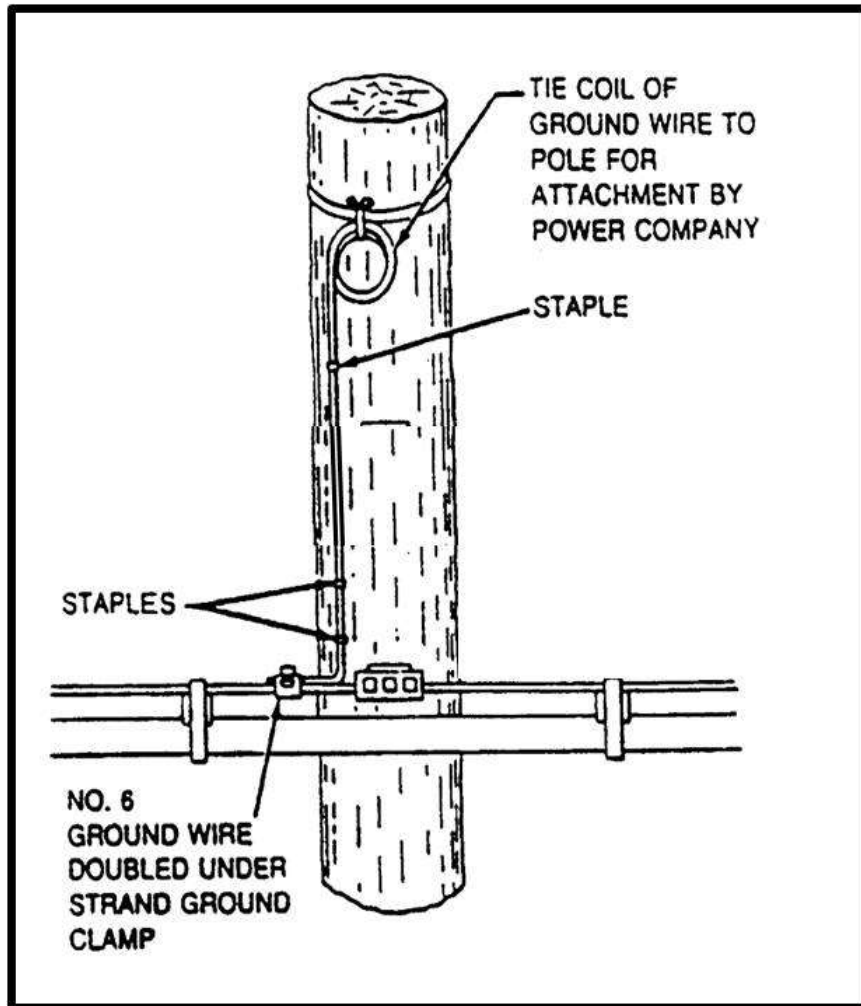


Where the connection to the power system neutral must be made above the communications space by the power company, estimate the length of wire that will be required, coil the estimated length of wire, and temporarily attach it to the pole for later connection by a power company employee. See [Figure 10-5](#).



For poles with multiple communications lines and messengers/strands, each strand should have its own dedicated ground wire and tie coil.

**Figure 10-5 Coiled Ground Wire Tied for Later Connection**

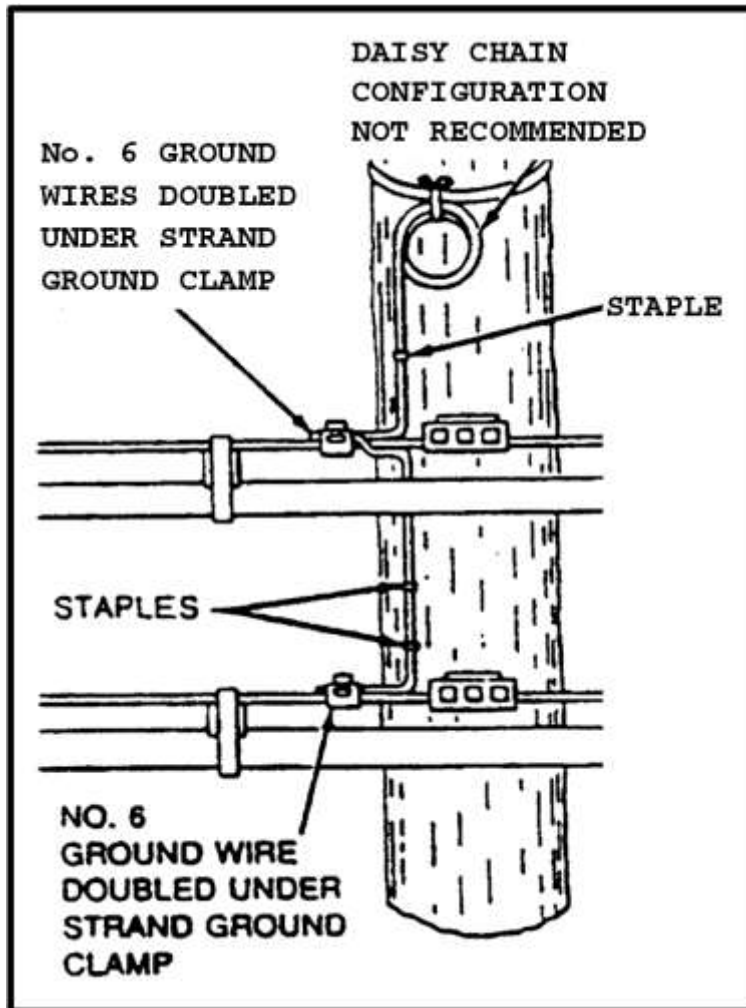


For poles with multiple communications lines and messengers/strands, each strand should have its own dedicated ground wire connection to the MGN.

The grounding connection as shown in [Figure 10-6](#), where the connection goes from one strand to a second strand and then to the MGN (daisy chaining), is not recommended and shall be avoided in buried plant. Although the “daisy chain” configuration shown in [Figure 10-6](#) does reduce the number of connections needed to be made by the electric supply company, it can introduce a possible safety problem. If the bond to the

second (upper) strand was to be broken or disconnected, then the first (lower) strand would become ungrounded and create a possible electrical hazard and degrade the effective grounding and protection scheme for the aerial plant (both communications and power facilities).

**Figure 10-6 Daisy Chain Configuration (Not Recommended =**

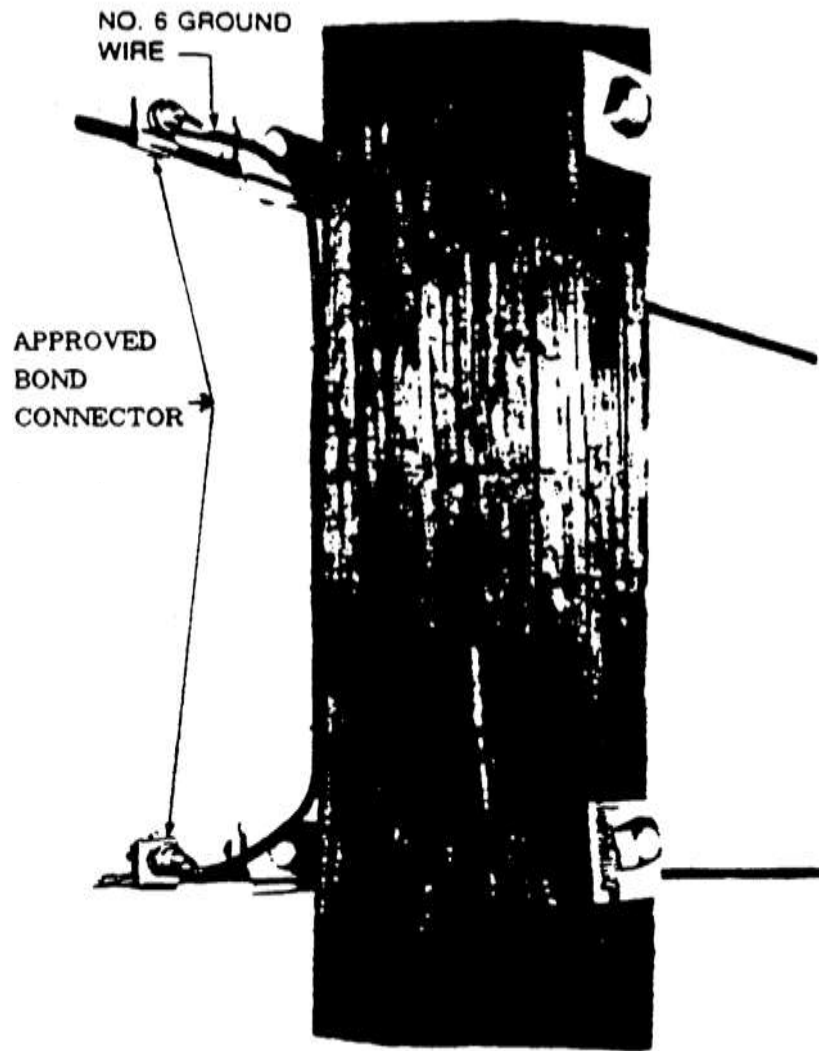


The first and preferred choice is to separately bond each communications strand to the MGN as per [Figure 10-1](#) with a No. 6 AWG ground wire and an approved connector.

Parallel strands supported on separate suspension bolts shall be bonded as shown in [Figure 10-7](#). ***Place the bonds at the first and last poles and where there are existing connections to the MGN.*** Parallel strands supported on

the same suspension bolt are electrically connected through the suspension bolt, and additional bonding is not required.

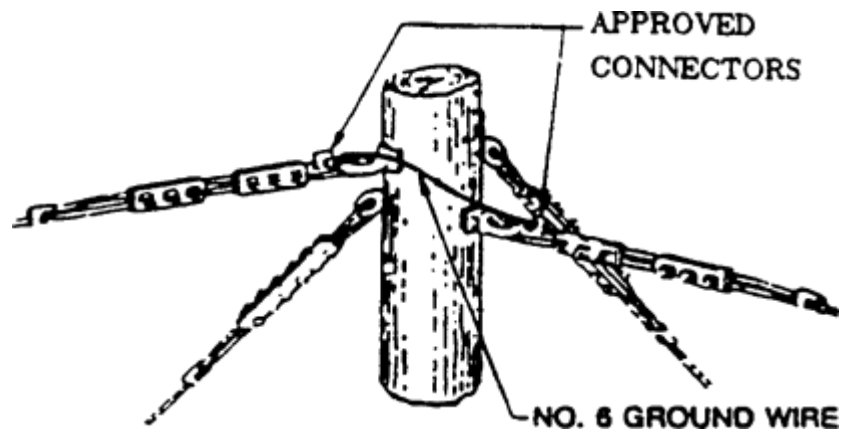
**Figure 10-7 Bonding Parallel Strands**



***Self-supporting cable on separate suspension bolts must be bonded. Parallel strands of self-supporting cable, supported on the same suspension bolt, are not considered electrically connected and must be bonded.*** Use two C or D connectors (or equivalent) and an appropriate length of No. 6 AWG ground wire in the same manner as shown for bonding strand.

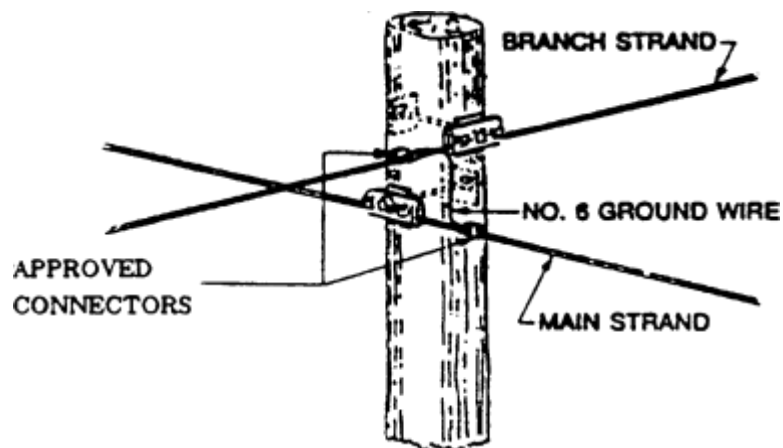
Continuity of suspension strand must be maintained. Any break in strand continuity shall be bridged with a permanent bond as shown in [Figure 10-8](#).

**Figure 10-8 Maintenance Strand Continuity at Corners**



Branch strands shall be bonded to the main strand as shown in [Figure 10-9](#).

**Figure 10-9 Bonding Branch Strand to Main Strand**



## 10.4 Grounding Guys

***All guys must be grounded or insulated (NESC Rule 215C)***

Grounding is accomplished by electrically connecting the guys to a grounded communications cable-suspension strand, or by connecting the guy to the vertical ground of an MGN power system. Where guy and strand are attached to the same guy bolt or cable-suspension bolt, they are electrically connected (bonded).

Examples are shown in [Figure 10-10](#), [Figure 10-11](#), and [Figure 10-12](#). Refer to [Section 10.4.1](#) for guys associated with self-supporting cables.

Refer to [Section 10.4.2](#) for guys not electrically connected through the guy bolt or suspension bolt.

**Note:** Nothing in NESC Rule 215C limits a portion of a guy or span wire from being insulated, as described in [Chapter 7](#), while another portion is being grounded.

**Figure 10-10 Guy Grounded at Corner**

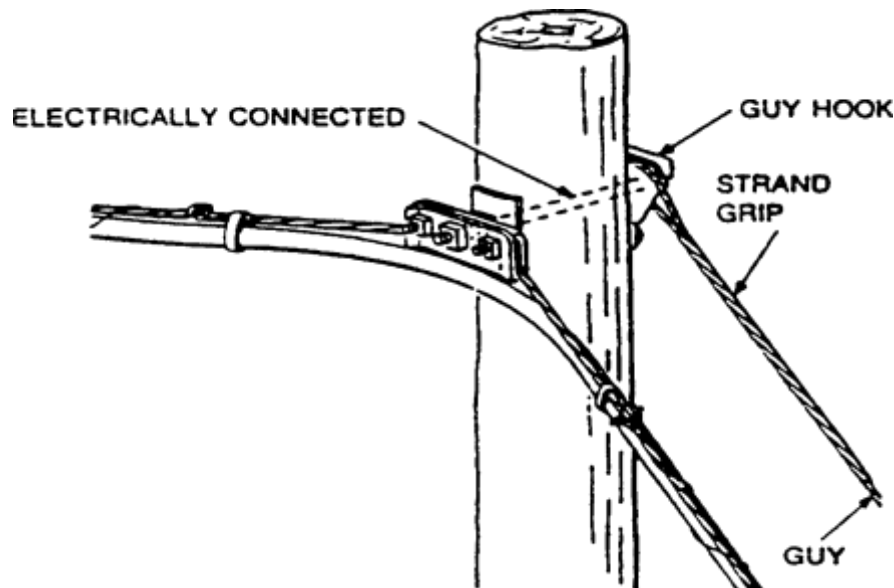
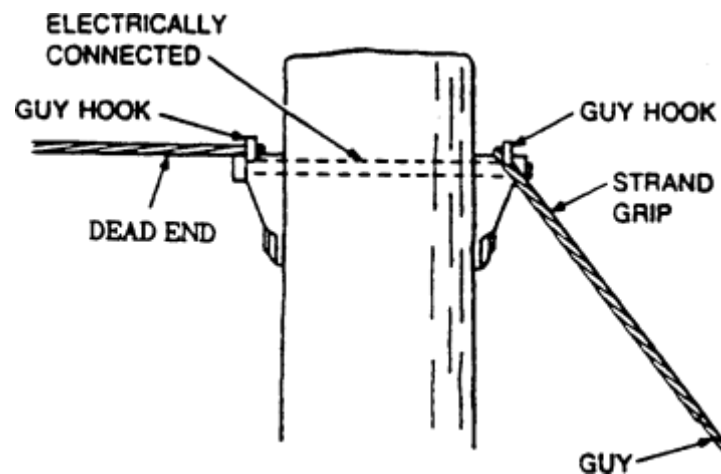
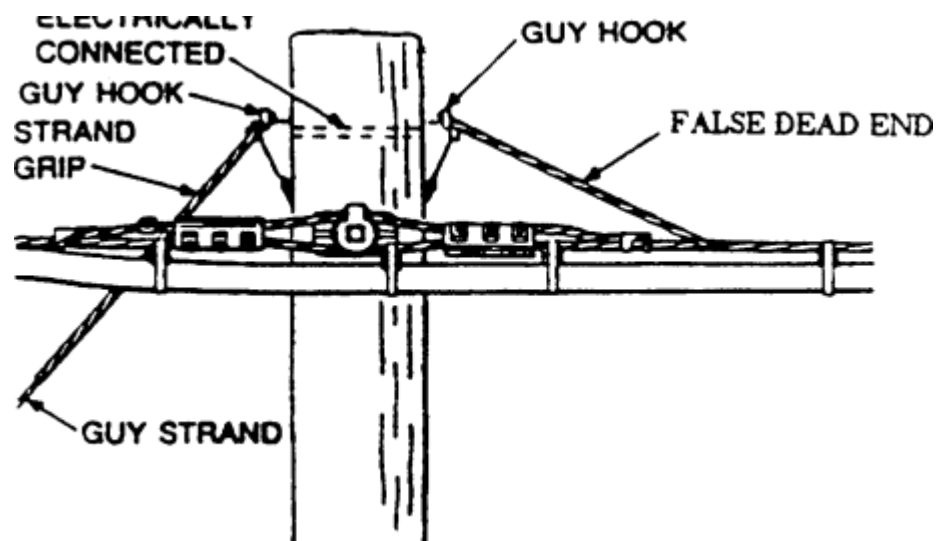


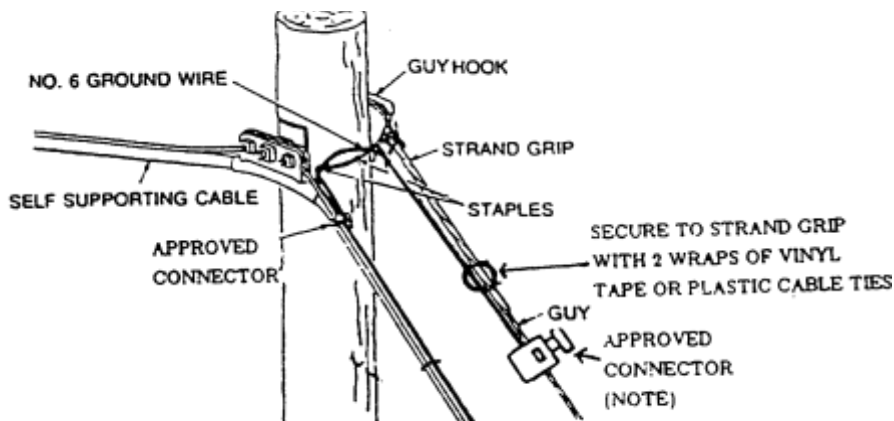
**Figure 10-11 Guy Grounded at Dead-End****Figure 10-12 Guy Grounded at False Dead-End**

### 10.4.1 Self-Supporting Cable

Where self-supporting cable is involved, only guys connected to the same bolt as false dead-ends and full dead-ends are considered to be electrically connected.

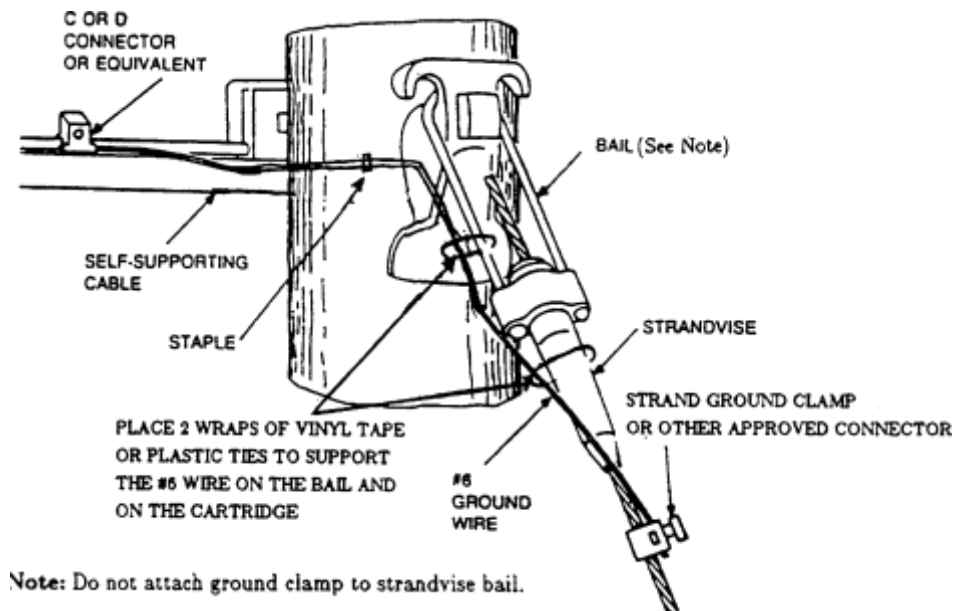
Corner guys connected to bolts carrying self-supporting cable are not considered electrically connected. An electrical connection may be made using a length of No. 6 AWG ground wire as shown in [Figure 10-13](#) or [Figure 10-14](#).

**Figure 10-13 Grounding Guy to Self-Supporting Strand**



**Note:** Place connector on guy strand beyond strand grip.

Do not connect ground wire to a strandwise bail. Connect ground wire to the guy with an approved clamp or strand ground clamp as shown in [Figure 10-14](#).

**Figure 10-14 Grounding Guy Where Strandwise Is Used on Self-Supporting Cable**

#### 10.4.2 Guys Not Electrically Connected Through Guy or Suspension Bolt

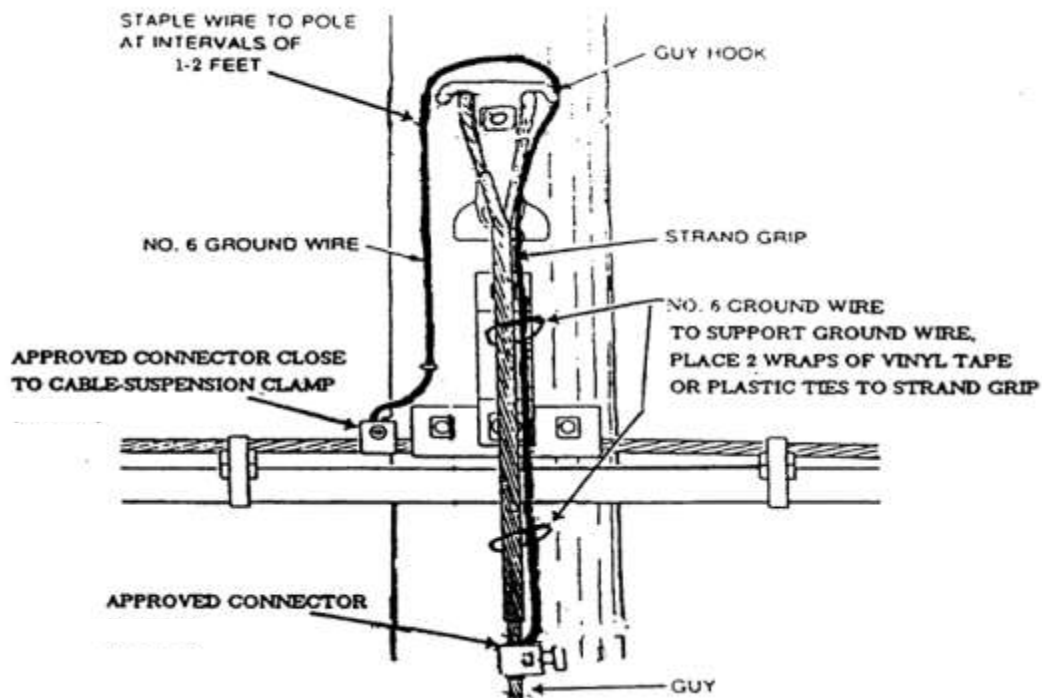
Where guys are not electrically connected through the guy bolt or cable-suspension bolt, use a piece of No. 6 AWG ground wire and two approved ground clamps as shown in [Figure 10-15](#).

With 25 M strand, or with 2.2 M strand not terminated with a strand grip, use a strand ground clamp. Double the wire back on itself for at least 1 inch when using the strand ground clamp. The connection to 2.2 M strand may also be made by a 1-bolt guy clamp, with one half of the clamp rotated so that 2 sets of grooves are at right angles to each other. In all cases, the wire shall be firmly stapled to the pole. Staples or other approved fasteners must be 1 to 2 feet apart.

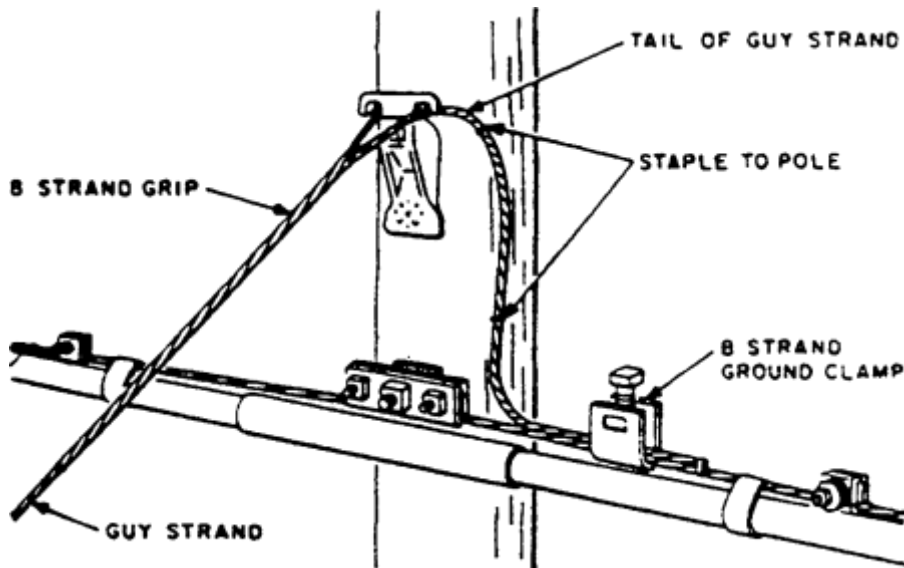
[Figure 10-16](#) shows how the tail of the guy strand can be used as a bond where guy hooks and strand grips are used on the pole. This method may also be used with strandvises.

**Note:** It is recommended that the method shown in [Figure 10-16](#) be the first-choice method used on new or replacement guy construction.



**Figure 10-15 Grounding Guy That Is Not Electrically Connected Through Guy Bolt**

**! CAUTION !** On joint-use poles, the length of the tail must not exceed 3 feet so it cannot accidentally whip up into the power wires. The tail should be as short as practical while not have any sharp bends.

**Figure 10-16 Bonding with Tail of Guy Strand**

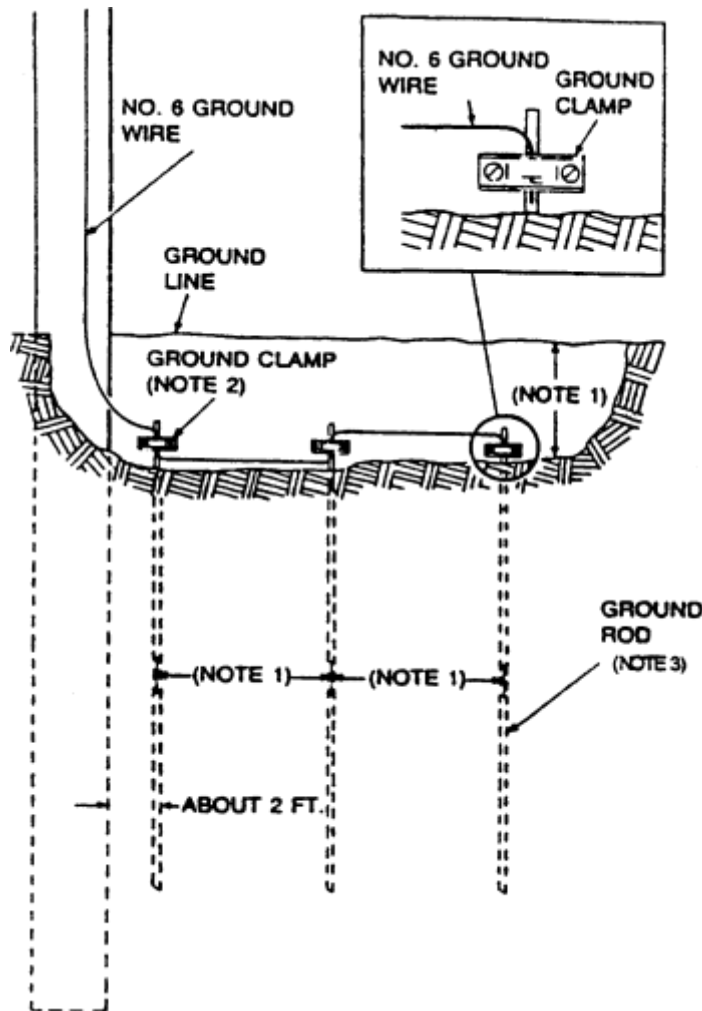
### 10.5 Bonding and Grounding Where There Is No Access to the Power MGN System

Where aerial plant is exposed to severe lightning and there is not access to the power MGN system (non-joint construction), special bonding and grounding measures are required for communications hardware.

Multiple cable-support strands must be bonded together at 1/4-mile (400 m) intervals, at each crossover, and at branch locations. Where special grounding measures are required, driven ground rods must be placed at intervals specified. The number of ground rods and the distance between them must be specified by the ICEP engineer. [Figure 10-17](#) shows a typical ground rod arrangement.

If an un-insulated guy is present and it is electrically connected to the cable strand, consider it to be equivalent to a driven ground rod (i.e., considered to be an acceptable ground).

All bonding and grounding connections along the cable lead are made using the same methods and hardware as previously described in [Section 10.3](#) and [Section 10.4](#) for joint-use plant.

**Figure 10-17 Connection to Ground Rods**

- Note:** [1] Spacing, number of ground rods, and depth of trench are to be specified on construction drawings. In general, ground rods must not be installed closer to each other than the length of the rod used. Larger separations are preferred, but accessible space within the accessible right-of-way often limits the ground rod configuration choices. The top of the rods would usually be located 4-to-6 inches (nominal) below the surface.
- [2] Connect the No. 6 AWG ground wire conductor directly to the ground rods with ground clamps. A crimped or welded connection would be better electrically and mechanically; however, a screw-type connection would be easier to install in the field and unscrew for testing the connection to earth. A two-lug ground connector/clamp is preferred.
- [3] Ground rods must be a minimum of 8 feet long and a minimum trade size diameter of 5/8-inch if constructed of iron or steel, or 1/2-inch if constructed of stainless steel or copper-clad stainless steel.

### 10.5.1 Bonding and Grounding Where Access to Power MGN System Is Denied

Although the desirable practice is for communications ground to be bonded to the power grounding MGN system, some power utilities (particularly in some USA Western States) do not permit communications attachments to their MGN. Other power utilities do not utilize an MGN grounding scheme, but have other schemes such as Delta, Wye, single-point grounding, ungrounded, or hybrid circuits.

If permission to bond is denied by the power supply company, then contact the ICEP engineer for specific guidance in the area. In general, a good connection to ground (earth) is an objective to help provide high-quality, low-noise service. Therefore, a separate communications ground bed consisting of at least three ground rods as discussed above and shown in [Figure 10-17](#) may be required.

Although two rods should be sufficient to obtain an adequate earth connection, three interconnected rods is often deemed a good compromise for universal guidance given that the local soil conditions and environmental variations may not be known.

More than three interconnected rods are not necessary or may be unwise in some circumstances. If the communications ground becomes the best (lowest impedance) path to ground in the neighborhood, then it will also become a preferred path for lightning and power fault currents. If there is a series of these ground beds adjacent to and along a supply pole line, then there is a communications line parallel to the aerial power cables that may lead to induced voltages in the communications shields and cable pairs.

## 10.6 Bonding Metallic Components of Optical Cable to Support Strand

Optical fiber cable that is considered all dielectric (no metallic components) does not require bonding to the support strand. The support strand must be bonded and grounded using the same procedures covered for metallic conductor cables (see [Section 10.1](#) through [Section 10.5](#)).

Optical fiber cable that has metallic components associated with its design must be bonded to the cable support strand. Methods for constructing these bonds depend on the cable design.

The location of sheath-to-strand bonds for optical cable can vary from those required for metallic conductor cable. Bonds must be placed between the optical fiber cable metallic components and the support strand at convenient splice locations, but at least every 1-1/4 miles (2 km). Where the distance between splice points is greater than 1-1/4 miles (2 km), refer to the following paragraph before making additional sheath openings.

Under certain power-exposure conditions, the sheath-to-strand bond spacing may be increased beyond 1-1/4 miles (2 km). Approval and guidance must be

obtained from the communications company ICEP engineer for any reduction in the frequency of the bond spacing. Even for such special cases, a general rule should be that the bond spacing should not exceed 2 miles, and never be more than 3 miles.

## 10.7 Grounding and Bonding on Metallic Poles

For effective grounding, a working relationship and coordination with any joint-use power companies on metallic poles will be required. Within this caveat, the options available for bonding to, and grounding of, plant attached to metallic poles include:

- Making a solidly bonded connection to the metallic pole and rely on the metal pole material as the connection means to earth (ground).
- Making ground connections through the standard procedures described earlier in this chapter, i.e., from the strand through grounding wire connections that vertically run down the pole and reach earth through a separate ground rod system.

The solidly bonded connections to the metallic (steel) pole needs to provide a low-resistance connection and strong mechanical strength bond. Options to consider would include:

- Attach to a grounding pad or grounding nut in the pole, if present. If a pole is known to be used or is likely to be used for joint use (power and telecom), then the pole could be ordered with a grounding pad/nut installed at a specified height (e.g., 28-30 feet from the base = allow for 6 feet in ground and assume communications plant will usually be attached around 22-24 feet).

**Note:** A pole step could also be a bonding point to the metallic pole, but it would not be recommended since the connection would be too easily damaged by pressure from, or movement of, a worker's shoe or hand.

- Drill a hole into the pole and place a grounding pad or nut – This should be relatively easy to accomplish with proper tools, but is likely to not be desirable from the pole owner's or power company's standpoint.

**Note:** A review of industry web sites and catalogs finds various hardware configurations with typical hardware of (a) ½ inch diameter threaded insert, or (b) a TEK50 steel fastening screw. Drilled holes would be best made with either a hole saw or stepped "Christmas tree" style of bit; with a rotabroach device recommended as a preferred drill bit since it requires less energy (or force) to drill the hole, resulting in less possible damage to the steel wall of the pole. Drill speeds should be limited to around 300 rpm or less.

- Weld a grounding pad or nut to the surface of the pole – This process could be a little difficult to do on site and could also include significant extra costs associated with additional equipment, labor, skill and time required for such welding work.
- Banded connection – Such a connection is not expected to provide a

sufficiently reliable electrical bond. A banded connection could loosen too easily or corrode and thereby make a high resistance bond. One could treat the metallic pole surface to get a better electrical/mechanical connection with processes such as acid-etching, physical scraping or roughening of the surface, or adding

electrolytic paste/adhesive for connection to the pole. Long-term reliability of these methods would still need to be tested under environmental and fatigue tests (e.g., through a test program designed around GR-3174 or other equivalent pole hardware specification).

The above connections all rely on the owner/installer of the metallic pole grounding that pole either through connection to a separate ground rod at the base of the pole, or through intimate contact of the exposed metal bottom of the pole with the surrounding earth (see “*Grounding Equivalency of Steel Poles*” by J. Patrick Donohoe). The ground connection can be through the main steel casing or

through the bearing plate at the base of the pole. In some corrosive soil environments, the bottom section of the metallic poles may have components parts protected under a plastic coating. In general, if communications plant (strand, grounding conductor) are solidly bonded to the steel pole, then the plant is assumed to be effectively grounded through the conductive steel pole contact with the earth.

An alternative approach would be to make a ground connection from the strand or communications equipment through a grounding wire connection that runs vertically down the pole and reaching earth through a separate ground rod system. Also, the ground connection may be made from the communications strand and plant through bonds to the communications guy/anchor systems. These connections are the same as those described in previous sections of this chapter.

## 10.8 Grounding and Bonding for Fault Managed Power System Circuits

To accommodate the high demand for enhanced wireless communications, a large number of wireless antenna and associated equipment will need to be added in the coming few years. All these wireless facilities will require power for their operation and various configurations are being designed and trialed; including remote power circuits (also called span powering) incorporated inside twisted pair and hybrid (fiber/twisted pair) communications cables as well as new powering scheme known as Fault Managed Power System (FMPS).

These FMPS circuits are designed to meet the requirements of ATIS Technical Report #0600040 Fault Managed Power (FMP) Distribution Technologies – Human Contact Fault Analysis, a subtending document – ATIS-0600040.01 Fault Managed Power Systems – Interlock Equipment Barriers for Limiting Access to Energized Conductors and Terminals via Contact Preclusion, and related standards Articles (722 and 726 of 2023

NEC, and UL (Underwriters Laboratory) - UL 1400-1 Outline of Investigation for Fault-Managed Power Systems - Part 1: General Requirements which contains Listing requirements and testing protocols for FMPS equipment, and UL 1400-2 Outline of Investigation for Fault-Managed Power Systems - Part 2: Requirements for CL4 Cables for use with Class 4 (FMPS).

These FMPS circuits that comply with the above standards have system software that automatically and rapidly (under 10 milliseconds) deenergizes the circuit if a fault or contact is made – i.e., similar to the GFCI circuits in a home. 2022. Therefore for these circuits, cable shield and grounding connections are not required for safety. However, if cables with these FMPS circuits are supported on suspension strand (i.e., messengers), then the strand will need to be bonded as per earlier section of this chapter.

## 10.9 Ground Rods

The driven ground rods of choice used for the communications plant discussed in this chapter are 5/8-inch copper-coated stainless steel rods (8 feet). In general, the rod shall be zinc-coated steel, copper-coated stainless steel, copper, or stainless steel and shall have a diameter of not less than 12.7 mm (0.5 in).

- To meet the minimum 0.5 inch requirement, driven rods should be at least 5/8 inch trade size. For example, the diameter of a nominal 5/8 [0.625 inch] copper-coated steel rod varies from 0.555 to 0.565 inch whereas for a zinc-coated steel rod it varies from 0.539 to 0.555 inch.
- The use of aluminum and iron rods as electrodes are not considered to meet the general performance and corrosion requirements of 094A.

Longer rods or multiple rods may be used to reduce the ground resistance. Spacing between multiple rods should be not less than 1.8 m (6 ft).

The driven depth shall be not less than 2.45 m (8 ft). The upper end shall be flush with or below the ground level unless suitably protected.

With a general caveats or exceptions such as:

- Other diameters or lengths or configurations may be used if their suitability is supported by a qualified engineering study.
- Where rock bottom is encountered, driven depth may be less than 8 ft, or other types of electrode may be employed.
- When contained within pad-mounted equipment, vaults, manholes, or similar enclosures, the driven depth may be reduced to 7.5 ft.

See a fuller discussion of other made electrodes, comparisons of the various electrode types, and code discussions are found in Section 27.3.3.

## 10.10 Informative References for Bonding and Grounding of Aerial Plant

1. Telcordia (Bellcore) Practice BR-627-020-005, *Bonding and Grounding Aerial Plant (Metallic Conductor and Optical Fiber Cable) - General (1986)*.
2. GR-3174, *Generic Requirements for Hardware Attachments for Utility Poles*.
3. GR-3159, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles*.
4. *Grounding Equivalency of Steel Poles*, by J. Patrick Donohoe (1999 white paper prepared for American Iron and Steel Institute).



# 11 Identification Markers for Aerial Cable, Guys and Equipment

## 11.1 General Marking Information

The identification of cables is partly to enable the worker (communications, supply, or others) approaching the cable or working adjacent to it, can identify

—

1. The company owning and operating the cable – This information enables worker to contact cable owner (operator) with any questions or to inform them of a problem.
2. What type of communications cable it is – i.e., communications twisted pair, coaxial cable optical fiber cable, cable containing powering circuits for communications equipment, and so forth. This identification enables the worker to identify which cable he needs to work on and cables they should avoid. The worker needs to be very sure the cable they cut or endeavor to open is the desired cable. The identification can be achieved by several means:

- Markings on the cable jacket,
- Cable tags - colored tags, colored sleeves, or metal tags, or
- Distinctive ordering or positioning of cables on a pole (or within a handhole/manhole) such as having fiber cables highest.

Cable jacket markings can often have problems remaining readable after years exposed to the weather (sunlight, rain, snow/ice), being underground covered with soil.

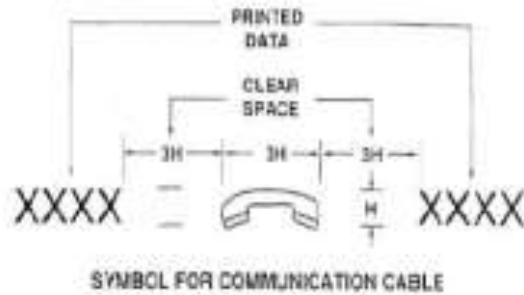
3. Cables containing powering circuits – With the greater use of circuits in communications cables for span powering, reverse powering, powering circuits for wireless antennas, and Fault Managed Power system circuits, these cables need to be clearly identified so that service is not disrupted and the appropriate work practices for these powering circuits can be employed.
4. AC Power utility supply cables - Communications cables and power utility supply cables should not usually share a handhole or manhole. In the unusual case of them both being present they should be separate by a barrier or mounted on opposite walls to avoid any confusion.

Other purposes of the cable identification and marking requirements are found in product specification documents and include:

**Traceability** - identify the manufacturer of the cable, the conductor types it contains and a date/plant of manufacturer - this is usually achieved with cable markings that include cable types, manufacturer name, gauge size,

conductor type and often has listing information if applicable. For example, UL listing per UL1400 for FMPS cabling.

**Cable Type** - The NESC Rule 350 prescribes a handset image to distinguish communications from AC power.



The information contained in the “XXX” printed mark should include

- The name(s) or symbol(s) of the communications company or utility (who to call for questions or to report problems),
- The manufacturer/supplier for traceability with year and information (or code or color ribbon) to identify place and date of manufacture,
- Cable type – including the handset symbol but also with information such as pair count, gauge, power levels, FMPS or span powering circuits. The cable type is often provided through a cable code for shorthand with the more detailed information contained on the cable reel label and recorded in a cable plant database.

## 11.2 Aerial Cable Marking

This chapter covers cable ties (identification markers) that can be placed by the licensee on cables, equipment, and guys so ownership can be readily ascertained. As poles become more congested with multiple joint users, it becomes more critical for the ownership of plant and its voltage, RF emissions and other operating characteristics of power, twisted pairs, optical fiber and wireless facilities to be clearly indicated to any worker on the pole. Such labels and marking will help protect the aerial worker and help minimize damage to the facilities. With multiple joint users on the pole, labels and markings are needed to provide contact information for the responsible person or company (plant owner/operator) for the aerial plant. Correctly identifying cables will help avoid accidental cutting into the wrong cables and more efficiently finding the cable that requires repair or maintenance work.

Markings and printed codes should be present on the outside of cable jackets that define the type and design of the cable and its core components.

However, these markings are not readable from ground level and may not be readily accessible or easily read after many years of weather exposure.

Therefore, colored labels and tags have proven useful for rapid identification and tracking of an aerial plant. The labels should be designed with weather-resistant materials and permanent marking.

However, they should also be designed to be easily replaced because of the damaging effects from long-term sunlight/weather exposure and physical abrasion, as well as the need to accommodate changes in network configurations.

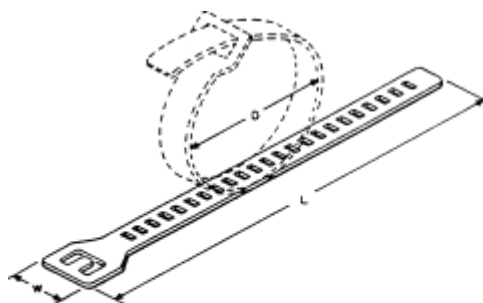
Identification of supply power cables and equipment is mainly achieved through placing the power cables inside guards/conduit, and the placement and separation of power facilities away from communications facilities (see Chapters 2, 3 and 14 for further discussions) on the pole. One exception can be that the vertical ground wire that descends the pole from the power space down to the ground electrode at the base of the pole could benefit from tags or identification. A tag or label should be placed on this power ground wire to indicate if a communications conductor (a) can be bonded to the vertical pole ground, or (b) should not be bonded since the vertical wire is grounding a lightning arrestor, surge arrestor or other supply device (see Chapter 10 for further discussion).

### 11.3 Cable and Equipment Identification Markers

There are several types of tags and markers available made of UV-resistant polyethylene, polyvinyl-chloride and other plastics. Metallic tags are also used with information engraved or embossed into the metal surface (see Chapter 19 for cable identification tags for underground plant in manholes).

For uniformity, the communications company may specify the use of certain types and colors that shall be used across a large geographic operating area so that workers can rapidly identify from ground level the ownership of plant on congested poles. From an operational perspective, some network providers have used colored cable jackets or colored conduits to distinguish different cable types or routes particularly for vertical riser installations where cables transition from underground or buried cable to aerial cable configurations (see Chapter 26).

The traditional plastic markers, shown in Figure 11-1, are available in various lengths, including 4-1/2-inch, 7-inch, and 9-1/2-inch sizes. The size, being the overall length, is selected in accordance with the diameter of the cable or guy on which the marker will be attached.

**Figure 11-1 Identification Marker (Cable Tie)**

| L     | W     | D   |       |
|-------|-------|-----|-------|
|       |       | MIN | MAX   |
| 4-1/2 | 11/32 | 1/4 | 1-1/8 |
| 7     | 5/8   | 3/8 | 2     |
| 9-1/2 | 1-1/4 | 3/4 | 2-1/2 |

ALL DIMENSIONS ARE IN INCHES

|                       | W                     | D           |                       |
|-----------------------|-----------------------|-------------|-----------------------|
|                       |                       | M<br>I<br>N | M<br>A<br>X           |
| 4<br>-<br>1<br>/<br>2 | 1<br>1<br>/<br>3<br>2 | 1<br>/<br>4 | 1<br>-<br>1<br>/<br>8 |
|                       | 5<br>/<br>8           | 3<br>/<br>8 | 2                     |
| 9<br>-<br>1<br>/<br>2 | 1<br>-<br>1<br>/<br>4 | 3<br>/<br>4 | 2<br>-<br>1<br>/<br>2 |

All dimensions are in inches

The markers are readily available in many colors, including blue, orange, green, brown, and slate. The 9-1/2 inch size is also available in red or yellow. Yellow has often been reserved for optical fiber cables, and red is often associated with power facilities. Each licensee that attaches facilities to a pole is requested to use the markers. The communications company or pole owner may designate the color and the type of marker to be used.

It is desirable that the tags be personalized with a company name and contact information, as illustrated in [Figure 11-2](#). In addition to the communications company initials, the licensee's name should be placed at the bottom of the tag. The tags are available in several colors and sizes. The larger tag are used on cables, and the smaller tags are recommended for use on the licensee's terminals, closures, or other apparatus. Cable ties can be used to attach the tags to convenient places of the equipment closures.

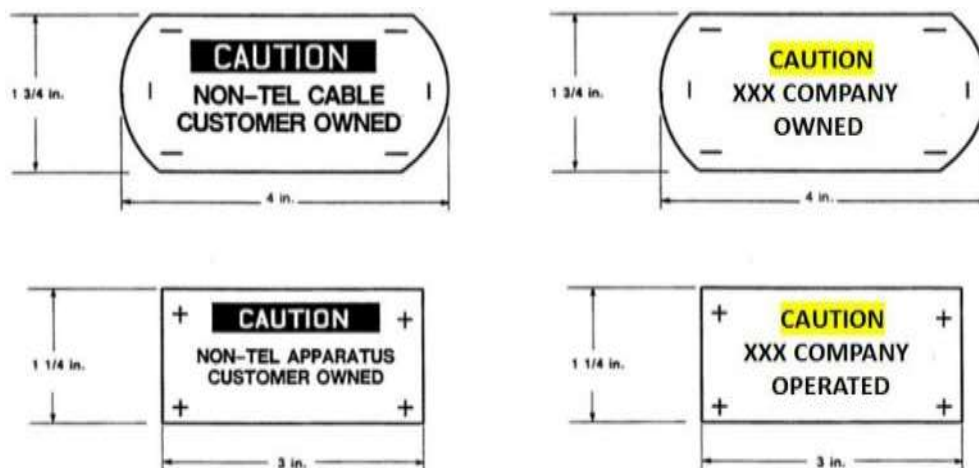
Markers and labels are required to identify plant ownership/responsibility and to provide the workers with relevant safety information. For example, see:

- [Section 3.8](#) for use of reflectors and clearances for poles near traffic roadways
- [Section 12.4.6](#) for tags for identifying defective poles
- [Section 15.3](#) for specific guidance on RF exposure labels for wireless facilities.

The label should include sufficient information to uniquely identify the installation and cable run, along with a contact number or information to obtain further details if necessary. From a logistical standpoint, the full and detailed information for a particular location may be better centralized to the Network Operations Center (NOC) and be accessible through a call to the NOC with the unique identifying number from the tag/marker.

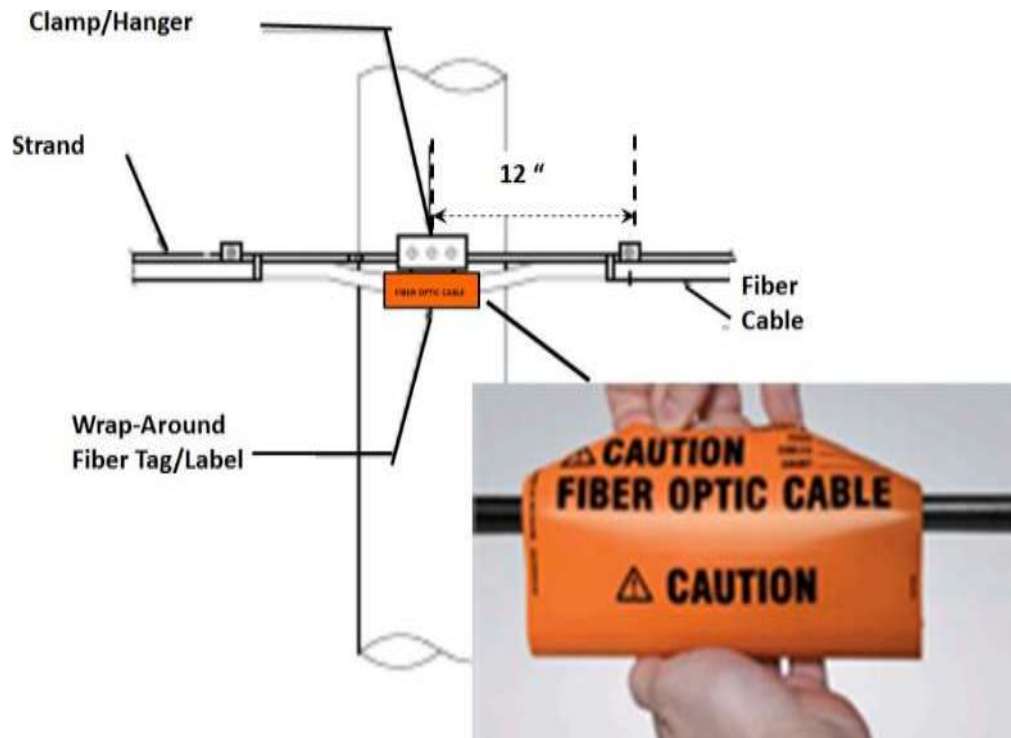
Tags used by the licensee must be approved by the communications company. The licensee may contact the communications company for vendors or specifications for tags of the proper materials and preferred designs.

**Figure 11-2 Custom Cable Tags**



Where "XXX COMPANY may be a wireless service provider or a cable TV operator for example.

Another cable marker product that has become more widely used for fiber cables is the wrap-around colored markers shown installed just below the cable clamp in [Figure 11-3](#).

**Figure 11-3 Wrap-Around Cable Marker**

#### 11.4 Installation of Cable and Equipment Markers

The markers, with or without tags, must be wrapped around the cable at the pole either under the suspension clamp or just between the suspension clamp and spacer (see Figure 11-3 as an example). When more than one cable is on the same suspension strand, it is not necessary to mark each cable. ***One (1) marker per pole or per strand is all that is necessary unless there are several different communications companies attached to the pole. In that case, the plant of each company should be identified and marked.***

Markers must be placed at each pole that supports a communications company cable for leads of 10 poles or less. If more than 10 consecutive poles are involved, it may be permissible to place a tag on every fourth pole.

## 11.5 Guy Markers

One of the underlying concerns of NESC Rule 217C, *Protection and Marking of Guys*, is to have adequate warning markers for guys and anchor rods that are in, or immediately adjacent to, the path of pedestrians. A pedestrian path is either a sidewalk or other readily identifiable path where persons traveling from place to place would be normally encountered or reasonably expected. There is no intent to require markers at all anchor guy locations where it is “possible” to access that location by foot.

The traditional plastic guy marker is a UV-resistant yellow or orange polypropylene split tube that is 6-8 feet long. The marker can be pushed onto the guy wire through the split edge and positioned as follows. At each licensee anchor guy location, place the marker between the device used to secure the strand (i.e., strandvise, guy grips, or clamps) and the eye of the rod. On pole-to-pole guys, locate the marker between the device used to secure the strand and the pole attachment. Place the marker at the pole where the guy is dead-ended.

Other plastic materials, colors or colored patterns (e.g., orange strip on yellow marker) can be substituted providing the materials are UV- and weather-resistant and the coloring provides contrast with the surroundings. The more common marker colors are yellow, orange and white for high visibility. There is flexibility for when and when not to include the markers, guards or barriers for the guy.

Some installation examples provide guidance on how to best choose to meet the intent the rule:

1. The NESC rule does not require installation of guards on guys extending into a farm field where the only anticipated traffic would be a slow-moving farm tractor. However, if a specific area along the edge of a field has proven prone to problems with impacts from tractors, agricultural equipment, or animals, then adding a yellow marker or erecting barriers would be advisable.
2. If the area in the vicinity of a pole or anchor has vegetation as high as a person’s head (e.g., 5-6 feet), one can assume that this area is absent both vehicular traffic and pedestrian activity, and therefore no marker is required.
3. Parking lots or established parking areas are specifically noted in the NESC rule 217C2 as susceptible zones where either markers and/or barriers (usually metallic or concrete posts) are necessary and recommended to avoid contact between vehicles and people.
4. Children’s playgrounds and their vicinity would be a place where markers and barriers would be strongly advised. Where a playground is surrounded by wire or board fences, then hopefully the utility right-of-way or easement and any associated anchors will lie outside the fence.



5. If there are several guys attached to a single anchor rod or several anchor rods for a pole, then the most susceptible guy for contact needs to be marked. It is often difficult to ascertain which is more susceptible: the outer guy that may be closer to a road or footpath, or the inner guy (closer to pole), which may be more often used as a “shortcut” by pedestrians or bicycle riders. If such multiple guys are in an area that requires markers under the NESC Rule or by communications company internal practices, then the preferred practice would be to mark all guys.

The 2023 revision to Rule 217C will create the following revised rule -

*C. Protection and marking of guys*

1. *The ground end of anchor guys adjacent to regularly traveled pedestrian thoroughfares, or places where persons are normally encountered or reasonably anticipated, shall be provided with a substantial and conspicuous marker.*

**Note:** *There is no intent to require markers at all anchor guy locations.*

The safety role of markers on guys is reviewed above for children play areas, parking lots and so forth. The new rule requires every guy at vulnerable or susceptible locations should be marked. It is a cost effective practice (from a risk management view) to routinely mark every guy at vulnerable or susceptible locations, as will now be required. It is expected that multiple companies will cooperate as various multiple power and communications guys are placed on the same pole and even on the same anchor.

The requirement is applicable where the guy are exposed to pedestrians, independent of what markers are on other guys. It is recognized there are cases, such as double-guys on a single anchor, where the marker cannot fit over the two guys, but in general, for safety, markers should be placed based on the described exposure.

The judgment issue becomes on defining which guys are in areas “*where persons are normally encountered or reasonably anticipated*.” In areas along roadsides, guys going to their anchors in the undergrowth, among trees or dense bushes are unlikely to have people around them. However, some consideration is needed for future activity associated with road widenings or during mowing or farming activities in adjacent fields. From a general safety perspective, it may be a best practice to require all guys to have markers with an exception only allowed for guys and anchors that are in areas where pedestrians, persons (on foot or on bicycles), and vehicles are never expected or not likely.



## 11.6 Wireless Antennas and Equipment

The powering circuits and the supporting communications cables that serve wireless antennas and associated equipment will often run vertically up the pole since the antennas may be located at the top of the pole or out on crossarms or support braces while the powering and backhaul equipment are located lower down on the pole or are ground based locations in cabinets. Apart from RF exposure warning labels needed for the operating antenna (see Chapters 14 and 15), it is also useful to distinguish the individual vertical riser conduits that may be present. Color coding of the conduits can be employed to discriminate between supply cable risers, communications risers from underground plant, optical fiber runs and wireless related cable runs.

## 11.7 Informative References

1. GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*.

## 12 Pole Testing and Inspection

This chapter covers methods of testing poles to determine if the poles are capable of withstanding the loads required to meet operational forces and service carrying capacities, including storm loading conditions mandated by the NESC. Poles that have been given an approved and adequate preservative treatment will retain their strength for many years. Although pole failures may occur as a result of unusual conditions or inadequate preservative treatment, a failure of a pole is usually due to one or more of the following causes:

- Decay of the pole at or below groundline.
- Storm damage.
- Mechanical damage from automotive or other impact.
- Insect damage from termites, carpenter ants, or other insects.
- Lighting damage or fire damage.
- Woodpeckers.
- Application of excessive loads or creating unbalanced loads that can become too great under normal expected conditions (e.g., average storm or ice loading). Such loads may result from improper or inadequate construction or maintenance methods.

**! CAUTION !** *No work aloft shall be started unless the employee is satisfied that the pole line structure has adequate strength to support the load resulting from working aloft and the load which will result from the intended work operations. If the strength of the pole line structure is in doubt, supports must be applied before starting work.*

### 12.1 Pole Testing Prior to Work Operations

All poles must be visually examined before work operations are begun that involve pole climbing, placing a ladder against the pole or strand, hanging an aerial platform, riding the strand, or similar procedures where a load is placed on a pole. While making the visual examination, check for the following conditions and their possible root causes:

1. Any unexplained leaning of a pole that may be due to failure (decay) of the pole at, or below, the groundline. Other factors that contribute to pole lean can include:
  - Broken wires in adjacent span.

- Excessively tight or excessively slack drop or line wires on one side of the pole.
  - Insufficient depth of setting. This may be due to erosion of the earth around the pole as a result of heavy rainfall, flood water, road widening, etc., and would affect the stability of the pole.
  - Foundation failure because of:
    - Soft, wet, or loose soil around the pole
    - Presence of large stones, ground irregularities, or debris at the base of the pole.
2. Contact, or insufficient separation, between communications and power wires or other communications plant on the pole, adjacent to the pole, or across the span to the next pole or attachment point.
  3. Presence of markings or pole tags placed by a pole inspector or previous worker to indicate an unsafe pole or pole that needs to be replaced.
  4. Visible defects or external indications of internal defects, including the following:
    - Split tops or through cracks in the top of poles.
    - Lightning damage – evidence of burn marks from lightning strikes, conductor faults, or transformer failures.
    - Unusual cracking, shrinkage, or discoloration at the top of the pole; evidence of compression wood indicated by short horizontal cracks alongside of the surface of the pole, or by curling of wood away from the pole surface.
    - Unusual cracking or splits in the side surface.
    - Woodpecker holes.
    - Cracks and cross-breaks – for example, wide seasoning cracks that could result in loosening of pole steps and present a climbing hazard.
    - Insect damage – presence of termite or carpenter ant infestation, evidenced by mud channels or debris in the cracks, wood dust at the base of the pole, or movement of ants when the pole is struck with a hammer or other tool.
    - Decay in knots (also called “rotten knots”).
    - Excessive mechanical damage, e.g., evidence of collision damage particularly when a pole is at an exposed location along a highway.
    - Presence and distribution of large knots, multiple climber gaff splinters, unauthorized signs, aerials, clotheslines, and nearby interfering tree growth that may present a climbing hazard.
    - Shell or sap rot on cedar poles.
    - Presence of fungus growth in cracks or protruding from the pole

surface or on areas near the groundline where the wood appears water-soaked in contrast to surrounding wood. These systems usually indicate a condition of advanced decay in the interior of the pole.

In addition to visual inspection of poles, any hazardous conditions resulting from faulty or non-standard construction shall be noted that may affect pole loading or the ability to climb and work safely on the pole. For example, climbing hazards could include the following:

- Presence of ice on pole or steps
- Missing or loose steps
- Presence of vertical conduit or cable runs or multiple unauthorized signs
- Presence and distribution of large knots or multiple climber gaff splinters
- Nearby interfering tree growth or branches overlapping or in contact with the lines .

This initial visual inspection is used to ascertain if there is a pole, soil, or load condition that warrants correcting before beginning a work operation. Not all conditions listed here deem a pole unsafe to perform aerial work. This list, along with guidance in [Section 2.6](#), helps in bringing awareness to possible hazards.

No work aloft shall be started unless the employee is satisfied, based upon the visual inspection and any subsequent pole testing, that the pole line structure has adequate strength to support the load resulting from working aloft and the load that will result from the intended work operations. If the strength of the pole line structure is in doubt, supports must be applied before starting work.

In addition to the visual inspection described above, one or more of the physical tests for pole soundness and mechanical integrity listed in [Section 12.3](#) should be conducted before a work operation begins on a pole. The exceptions where no further tests other than the visual inspection is required are provided in [Section 12.2](#).

### 12.1.1 Congested Poles

In recent years, the increased number of licensees have placed more and more equipment on poles to provide the full array of desired broadband communications, monitoring, surveillance and Smart-Grid services. One can find congested or crowded poles because of:

- More Competition in Telecommunications – More Joint Users
  - Expansion of Broadband Services and Applications – Penetration of

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fiber technology deeper into the local loop with a need for more and larger node sites on poles, in pedestals, and in handhole locations. This increases the number of cabinets and large node sites required.

- Expansion of Wireless Services and Applications – Deployment of more antenna sites lower down on the pole on crossarms and support struts to provide maximum signal coverage. To serve the antenna and provide maximum backhaul capacity, there will be associated power supply equipment and cabling.
- The process to identify and attach wireless antennas and associated equipment to existing joint-use poles and structures has been explored in a new IEEE Guide P2939 (*Guide - Guide for Joint Use of Utility Poles with Wireline and/or Wireless Facilities*) where typical attachment sites are reviewed along with NESC minimum clearances necessary to meet. Owing to the number of competitors for space on poles, cooperation and clear Joint-Use Agreements (JUA) are necessary for efficient growth of networks (see Chapter 26 for further discussions on JUA components).
- Power Supply companies are also deploying more equipment to implement Smart-Grid plans and develop distributed power generation initiatives (e.g., pole-mounted solar panels)
  - Pole-mounted devices to monitor and control supply circuits
  - Network interconnection sites for Broadband-over-Power-Line (BPL) systems
  - Private lighting/luminary systems for parking lots and sports arenas.
- Municipalities and other utilities are adding cameras, antennas, and other systems to monitor, control, and support:
  - Traffic control
  - Enhanced security surveillance
  - Improved communications for emergency services – Police, fire, ambulance.

All these activities have resulted in more congested poles. If the applicable clearances and separation distances prescribed in the NESC and in this *Blue Book* are maintained, then sufficient climbing and working space should be attainable on the pole. However, the worker intending to climb a pole needs to ascertain the type of equipment that is present and if such equipment presents any unacceptable hazard to the completion of their work. The worker should report to their supervisor any instances of:

- Insufficient climbing space
- Insufficient working space
- Unlabeled or unidentified equipment attached to the pole.

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**! CAUTION !** No work aloft should be started unless the employee is satisfied that **no electrical or RF radiation hazard exists**, and that adequate working space for the safe completion of their work is available (see Section 15.2 and 15.3 for RF exposure and relevant RF labels).

## 12.2 Conditions Requiring No Physical Testing or Supplementary Support

In general, all poles should be tested prior to working aloft using the techniques discussed in Section 12.1 and Section 12.3, unless one of the following conditions (1, 2, 3, or 4) listed below is met.

1. **Age and Condition** - The pole brand indicates that the pole is 10 years of age or less and the visual tests of Section 12.1 show no reason for concern. It is still advisable to perform the sounding test of Section 12.3.1.
2. **No Support Needed** - It is unnecessary to make tests or to apply a temporary support before climbing a pole if any of the following conditions exist throughout the work operations, unless visual inspection indicates otherwise:
  - a. The pole is storm guyed<sup>1</sup> on four sides.

**Note:** Storm guying refers to extra guys added above the normal guys required for corners, crossings, dead ends, and long spans. These extra guys are designed for higher resistance of the pole line to damage from wind and ice effects. The need for such storm guying usually arises from local experience and specific knowledge of the pole line and local weather/climate conditions.
  - b. The pole carries two or more storm side guys and is configured with 6 M or better strand as described in 3(b).
  - c. The pole is part of an H fixture provided with head and back guys.
  - d. The pole is not in a straight section of a line, but is an adequately guyed corner pole and carries a load as described in 3(b) below.
3. **Temporary Support** - It is also unnecessary to make or apply temporary support before climbing a pole if all of the following conditions exist throughout the work operations, and the proposed work operations do not involve placing a heavy unbalanced load on the pole:
  - a. The pole is in a straight section of line, but is not a dead-end pole.
  - b. The pole is carrying a 6 M or larger suspension strand securely clamped to it and to each adjacent pole, and will remain so attached throughout the work operations.

- c. There is no downward change in grade at the pole.
  - d. Neither adjacent span length is in excess of 165 feet (50 m).
4. **Supplementary Support** - It is also unnecessary to make tests or to provide supplementary supports before climbing a pole if the following conditions exist:
- a. Instead of carrying a suspension strand, the pole carries 10 or more copper, copper steel, or steel line wires that will remain securely tied at the pole and at each adjacent pole throughout the work operation.
  - b. All other conditions described in 2 (a), (c), and (d) exist.

## 12.3 Physical Testing Techniques for Examining Poles

In addition to the visual inspection described in [Section 12.1](#), one or more of the following tests for pole soundness and mechanical integrity should be conducted before a work operation begins on a pole (see exceptions in [Section 12.1](#)).

### 12.3.1 Sound Test

Using an approximately 3-lb hammer (e.g., lineman hammer), strike the pole on all sides from the groundline to as high as can be reached.

The sounding test consists of applying blows with a hammer to the pole surface completely around the pole from points close to the groundline to as high as can conveniently be reached. The presence of a hollow condition or advanced internal decay can usually be recognized by the characteristic hollow or dull sound resulting from the blows on the wood.

**Note:** The old term of “hollow heart” is no longer used because, although the pole may be hollow and decayed, a pole such as southern pine may still have the heart intact. The term “advanced internal decay” is a more accurate and complete description of the condition.

A pole free from decay usually sounds clear and the hammer usually rebounds noticeably when the pole is struck sharply and squarely. Wet surfaces due to high soil moisture, wide cracks, or shakes in the pole near the surface may change the sound of a solid pole. Care must be taken not to mistake the altered sound due to these causes for the sound associated with internal decay. The traditional sounding with the 3-lb hammer relies on the experience and training of the lineman in the field.

### 12.3.2 Prod Test

Use a pole prod tool or lineman’s screwdriver with a shaft of 5 inches in length or longer. Insert the tool at a 45-degree angle below the groundline and attempt to force or strike the prod tool into the pole at two or three locations around the circumference of the pole. Wood decay will be evident by the ease with which the tool penetrates the pole. A sound pole should

firmly resist the prod penetration.

### 12.3.3 Prod Test - Below Groundline Inspection

Since decay most often occurs at and below the groundline, it is advantageous to excavate at the base of the pole to a depth of 6 inches and perform the 45-degree prod test below ground level. Excavation should be accomplished with hand tools depending on the soil type and time of year. It may be useful to break the ground with a digging bar or shovel if necessary.

**Note:** If one is unable to excavate (e.g., poles that are set in concrete and asphalt), the prod test at the groundline of the pole should be performed at 4 points, 90 degrees apart with the prod tool angled downwards at approximately 45 degree to better detect decay below the groundline.

**Note:** As an option for avoiding excavation, one can place the prod tool a few (2-3) inches from the pole surface and drive it at 45 degrees through the soil to make contact with and enter the pole 2-3 inches below the groundline. Although this method does allow a more rapid test, it is advisable to excavate if an indication of decay is found through this procedure.

When using the pole prod, place the point against the pole surface and push. Do not jab it into the pole since this action may well remove a slab of treated wood. This is important when inspecting poles of the shallow sapwood species (see [Table 12-1](#)). Removal of the thin treated sapwood will expose untreated heartwood to attack and decay by fungi and micro-organisms.

**Table 12-1 Examples of Wood Species by Sapwood Thickness**

| Thick Sapwood Species | Thin Sapwood Species |
|-----------------------|----------------------|
| Southern Pines        | Douglas Firs         |
| Ponderosa Pines       | Western Red Cedars   |
| Red Pines             | LodgePole Pines      |
|                       | Jack Pine            |
|                       | Western Larch        |

If convenient, sound the exposed pole section below the groundline for the presence of hollow heart or enclosed decay pockets.

If soil is excavated for this below groundline test, then replace the earth after the test is complete by firmly packing it around the circumference of the pole. If the earth replaced is insufficient to fill the hole and to make a small mound around the pole to compensate for settling, then obtain additional earth and use it for this purpose. Stones removed during the excavation for inspection should be replaced against the pole surface when backfilling.



### 12.3.4 Hand Line or Pike Test

An additional optional test is to use a hand line or a 12- to 16-foot pike to physically test the flexural rigidity of the pole.

The pike test shall not be used on poles with utility power attachments.

Loop the hand line over a firm attachment such as a pole step at least 12 feet above the ground, or make a loop and raise it up the pole with a raising tool. Then, pull the rope with ~30 lbs of force at right angles to the strand or in all directions if a strand is not attached. A sound pole properly placed and guyed should not easily move and should firmly resist the applied force. The hand line test can also help reveal inadequate soil conditions (e.g., soft soil or insufficient compaction) around the base of the pole.

### 12.3.5 Consequences of Physical Tests

If the results of the above physical tests indicate decay or an unsound pole, then:

1. The pole should not be climbed unless it is made safe by guying, bracing, reinforcement or other additional support means.
2. The pole shall be tagged as a problem pole and designated for replacement or further testing (additional sounding, prod or drilling tests).
3. The technician's supervisor shall be notified.

If soundings and prod tests are inconclusive, then supplementary examination with increment boring or drilling techniques may be necessary (see [Section 12.5](#)).

**Note:** Most pole inspection and treatment companies will place a weather-resistant tag or metallic disk to indicate when a pole was inspected or treated with additional preservative. These tags are typically found 4-6 feet from the groundline near the brand mark or pole owner's ID tag.

If internal decay is indicated by the visual and physical tests, the pole should be evaluated to determine the extent and degree of decay. To determine the quantitative characteristics of internal decay, a drilling or boring examination is usually needed. This internal pole inspection process is discussed in the next section.

## 12.4 Measuring Extent and Effect of Decay

### 12.4.1 Internal Examination of Pole - Hook Probe in Drilled Hole

If there is an indication of decay from the sounding or prod tests described above, then a drilling, boring, or equivalent test should be performed along with additional sounding and prod tests around the pole. Drilling or boring is used to determine the extent and thickness of the sound shell and the size and extent of underlying decay pockets.

The parameters required for a quantitative measure of the decay effect include:

1. Shell thickness of sound wood
2. Circumferential extent of decay zone around the pole
3. Depth and width of decay pockets and cracks
4. Orientation to the spans attached to the pole (e.g., in the line of lead or outside the line of lead).

The strength consequences and deduction allowance for a pole that is found to have internal decay is primarily based on the extent of decay as measured by sounding tests and the minimum shell thickness of sound wood that can be measured through visual and tactile inspection with a hook probe into a hole drilled into the pole.

1. A hole is drilled into the pole, and the surface condition of the hole is examined with a hook probe to detect differences in softness/hardness of the wood surface.
2. The hook probe is inserted into the end of the drilled hole and withdrawn steadily while applying downward pressure so the hook can “feel” along the surface of the boring.
3. The ease with which the hook slides over or penetrates into the wood is a measure of the decay state of the wood.
4. The hook will catch on any actual void so the depth and remaining shell can be measured.
5. The drilled hole is then filled with a plug of preserved wood or plastic sealed to prevent new decay in the bore hole.

**Note:** An older technique, which is no longer used, was to use an increment borer tool with a hollow bit that extracted a small diameter wood core sample. The wood along the extracted core was then examined to measure the depth of the sound wood and the extent of any decay.

To consider any alternative techniques to accurately measure decay, the technique needs to be fully evaluated to ensure that reliable, reproducible results are obtained that are consistent with the results obtained from the

traditional sounding, prodding and invasive hook/drill methods above.

For any inspection program or measurement technique, the caveat is that the process of determination of pole status and decay extent needs to be accomplished at a reasonable cost per pole.

### 12.4.2 Wood Pole Decay Patterns

Typical examples and patterns of internal decay are shown in [Figure 12-1](#).

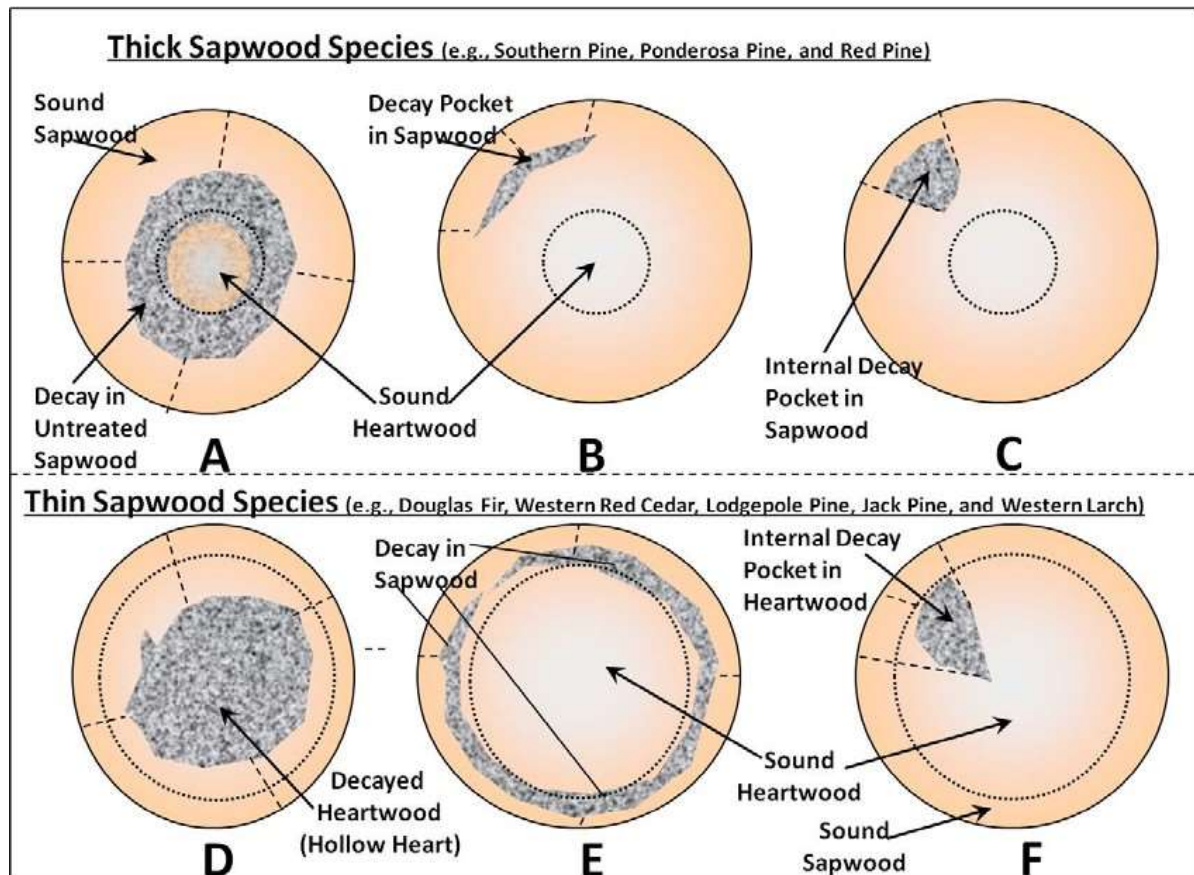
Poles in which the internal decay extends more than halfway around the pole, but which have a continuous shell of sound wood, shall be considered as having a **hollow heart**, regardless of the presence of a core of solid heartwood.

Poles in which internal decay extends less than one half of the circumference shall be considered as having a **decay pocket**.

Thick sapwood species tend to develop external decay below ground and over time that decay can progress up the pole, as shown in [Figure 12-1](#) (diagrams A-B-C).

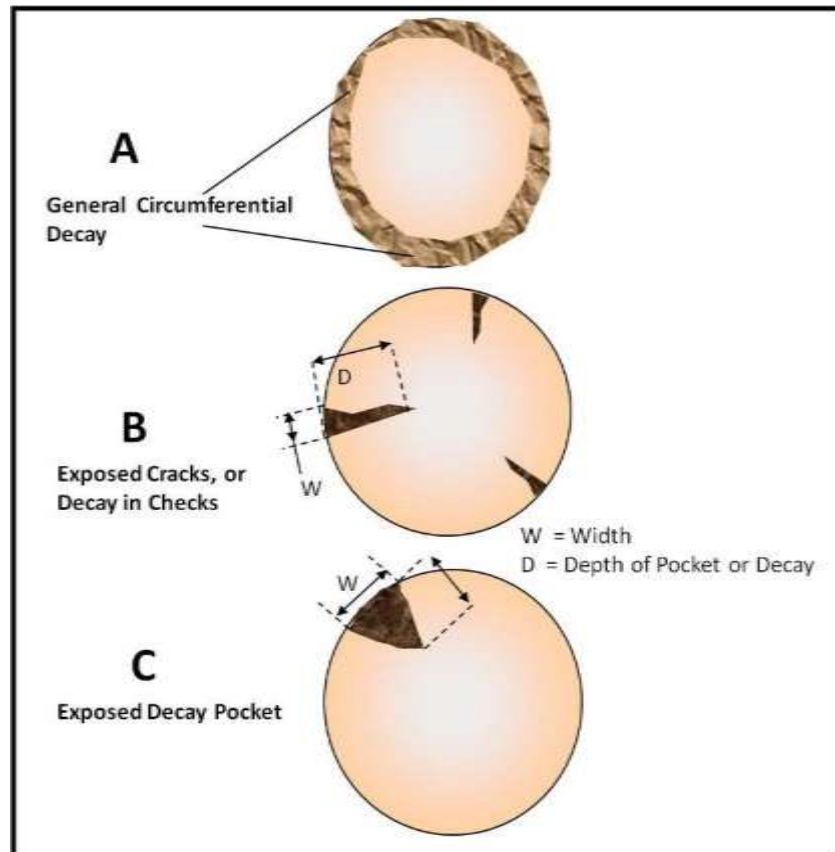
Thin sapwood species tend to decay more from the inside when the untreated heartwood is exposed after the pole moisture level reduces while in-service. It is rare that Douglas-fir develops any external decay as original treatment remains effective.

External decay may be around the circumference of the pole, progressing from the surface toward the center of the pole. It may be along cracks, giving the pole a fluted appearance, or it may occur as exposed pockets. Typical examples of external decay are shown in [Figure 12-2](#).

**Figure 12-1 Types of Internal Decay**

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**Figure 12-2 Types of External Decay**

### 12.4.3 Deductions for Defects

The remaining strength of a pole can be calculated based on measurements of effective circumference of sound wood, as modified by any quantified defects and decay present. Such calculations help determine whether a pole should remain in service or be replaced.

#### 12.4.3.1 Advanced Internal Decay

Effective strength measurements of poles with internal decay may be determined by applying correction factors by deducting amounts listed in [Table 12-2](#). For example, a pole having an outer circumference (after any external rot has been removed) of 30 inches, and a minimum thickness of shell of 2-1/2 inches, is equivalent in strength to a solid pole measuring 1 inch less (i.e., 29 inches) in circumference. To help the reader follow the above example, the relevant entries in [Table 12-2](#) are highlighted in red and underlined.

Table 12-2 Poles with Hollow Hearts

| Measured Circumference (in Inches) of Sound Wood | Minimum Thickness of Shell in Inches |                      |        |        |        |        |        |
|--------------------------------------------------|--------------------------------------|----------------------|--------|--------|--------|--------|--------|
|                                                  | 2<br>0                               | <u>2</u><br><u>5</u> | 3<br>0 | 3<br>5 | 4<br>0 | 4<br>5 | 5<br>0 |
| 20 to 21                                         | 1                                    | -                    | -      | -      | -      | -      | -      |
| 22 to 26                                         | 1                                    | 1                    | -      | -      | -      | -      | -      |
| 27 to 29                                         | 1                                    | 1                    | 1      | -      | -      | -      | -      |
| <u>30</u>                                        | 2                                    | <u>1</u>             | 1      | 1      | -      | -      | -      |
| 31 to 33                                         | 2                                    | 1                    | 1      | 1      | -      | -      | -      |
| 34                                               | 2                                    | 1                    | 1      | 1      | 1      | -      | -      |
| 35 to 37                                         | 3                                    | 2                    | 1      | 1      | 1      | -      | -      |
| 38 to 39                                         | 3                                    | 2                    | 1      | 1      | 1      | 1      | -      |
| 40                                               | 4                                    | 2                    | 2      | 1      | 1      | 1      | -      |
| 41                                               | 4                                    | 3                    | 2      | 1      | 1      | 1      | -      |
| 42 to 43                                         | 4                                    | 3                    | 2      | 1      | 1      | 1      | 1      |
| 44                                               | 5                                    | 3                    | 2      | 1      | 1      | 1      | 1      |
| 45                                               | 5                                    | 3                    | 2      | 2      | 1      | 1      | 1      |
| 46                                               | 5                                    | 4                    | 2      | 2      | 1      | 1      | 1      |
| 47 to 49                                         | 6                                    | 4                    | 3      | 2      | 1      | 1      | 1      |
| 50                                               | 6                                    | 4                    | 3      | 2      | 2      | 1      | 1      |
| 51                                               | 7                                    | 5                    | 3      | 2      | 2      | 1      | 1      |
| 52                                               | 7                                    | 5                    | 4      | 2      | 2      | 1      | 1      |
| 53                                               | 7                                    | 5                    | 4      | 3      | 2      | 1      | 1      |
| 54                                               | 8                                    | 6                    | 4      | 3      | 2      | 1      | 1      |
| 55 to 56                                         | 8                                    | 6                    | 4      | 3      | 2      | 2      | 1      |
| 57 to 58                                         | 9                                    | 6                    | 5      | 3      | 2      | 2      | 1      |
| 59                                               | 9                                    | 7                    | 5      | 4      | 3      | 2      | 1      |
| 60                                               | 10                                   | 7                    | 5      | 4      | 3      | 2      | 1      |

For the cited example of a 30-inch circumference pole with advanced internal decay, and a shell thickness of 2-1/2 inches of sound wood, the 1-inch circumferential reduction converts to a reduction of 7% in pole strength (i.e., the decayed pole retains 93% of its initial strength).

The minimum circumference criteria will be set by the design and engineering group of the communications company or pole owner based on

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their internal design criteria and objectives used for their pole line construction. The NESC recommends pole replacement after the pole strength has reached 67% of its design load (NESC Table 261-1, footnote 2).

The NESC-recommended criteria for restoring or replacing a pole is when the remaining strength is 67% or less of the required strength (NESC Table 261-1).

As general operational strategy to avoid any pole from ever reaching such minimum values (67%), pole inspections and rehabilitation work should follow the guidelines in Sections 12.5 and 12.6, as well as the following general principles:

- Poles calculated to have less than 85-90% strength remaining shall be monitored on an accelerated inspection schedule, and
- Poles with less than 75-80% strength remaining shall be scheduled for restoration with a steel truss or replacement.

#### 12.4.3.2 Enclosed Pockets

For poles having enclosed pockets on one side or near the groundline, the measurements shall be corrected by deducting the amounts listed in Table 12-3. In this table, depth refers to the maximum depth of radial dimension of the pocket.

For example, the table would predict that that a pole having a 30-inch measured circumference, a minimum shell thickness of 2 inches, and a pocket 5 inches deep, is equivalent in strength to a solid pole with a circumference of 1 inch less; i.e., a 29-inch pole. The 1-inch circumferential reduction converts to a reduction of 7% in pole strength (i.e., the decayed pole retains 93% of its initial strength).

**Table 12-3 Poles With Enclosed Pockets**

| Measured Circumference<br>of Sound Wood (Inches) | Shell<br>Thickness<br>(Inches) | Maximum Depth of Pocket<br>(Inches) |          |          |
|--------------------------------------------------|--------------------------------|-------------------------------------|----------|----------|
|                                                  |                                | 3 Inches                            | 4 Inches | 5 Inches |
| 22 to 30                                         | 1                              | 2                                   | 2        | 3        |
| 22 to 30                                         | 2                              | -                                   | 1        | 1        |
| 22 to 30                                         | 3                              | -                                   | -        | -        |
| 31 to 38                                         | 1                              | 2                                   | 3        | 3        |
| 31 to 38                                         | 2                              | 1                                   | 1        | 2        |
| 31 to 38                                         | 3                              | 1                                   | 1        | 1        |
| 39 to 50                                         | 1                              | 2                                   | 3        | 4        |
| 39 to 50                                         | 2                              | 1                                   | 2        | 2        |
| 39 to 50                                         | 3                              | 1                                   | 1        | 1        |

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### 12.4.3.3 Exposed Pockets

Measurements of poles having exposed pockets of varying shapes and dimensions near the groundline shall be corrected by deducting the amounts listed in [Table 12-4](#), where width refers to the horizontal width at the outside of the pole, and depth is the deepest distance obtained by measuring at right angles from a straight edge placed across the pocket. The prod tool noted in [Section 12.3.2](#) can often be used to measure the depth.

As an example, [Table 12-4](#) lists that a pole having a measured circumference of 30 inches, and an exposed pocket 4 inches wide and 2 inches deep, will be equivalent in strength to a solid pole circumference of 4 inches less than the initial 30 (i.e., equivalent to a 26-inch circumference pole). The 4-inch circumferential reduction converts to a reduction of 25% in pole strength (i.e., the decayed pole retains 75% of its initial strength).

Measurements of poles having external decay around the circumference shall be corrected by:

- Measuring the average depth of decay and deducting 6 times the depth from the circumference of the pole measured just above the decay.
- Scraping away the decay and measuring the residual circumference. This is not recommended unless the pole is to be given a supplementary groundline remedial treatment as discussed in [Section 12.6](#). Although it is possible to scrape away the decayed sapwood down to sound wood and thus rehabilitate the pole, this process is not recommended because the implications from the first decay process are numerous and include that the
  - Wood may not be adequately preserved and will decay again unless extensively treated with new preservative solutions or pellets.
  - Decay process that deteriorated the pole initially will start again with the newly rehabbed pole.
  - Decay below ground where the pole cannot be readily rehabbed without extensive excavation is likely to be worse than the rehabbed areas above the groundline.



**Table 12-4 Poles With Exposed Pockets**

| Depth of Pocket (Inches) | Width of Pocket (Inches) |   |   |   |   |   |    |    |
|--------------------------|--------------------------|---|---|---|---|---|----|----|
|                          | 1                        | 2 | 3 | 4 | 5 | 6 | 7  | 8  |
| 1                        | 1                        | 1 | 2 | 2 | 3 | 3 | 4  | 5  |
| 2                        | 1                        | 2 | 3 | 4 | 5 | 6 | 7  | 8  |
| 3                        | 1                        | 2 | 4 | 5 | 6 | 8 | 9  | 11 |
| 4                        | 2                        | 3 | 4 | 5 | 7 | 9 | 10 | 13 |
| 5                        | 2                        | 3 | 4 | 5 | 7 | 9 | 11 | -  |

An example using [Table 12-4](#): A pole having (1) a measured circumference of 30 inches, and (2) an exposed pocket 4 inches wide and 2 inches deep, will be equivalent in strength to a solid pole circumference of 4 inches less than the initial 30 (i.e., equivalent to  $30 - 4 =$  a 26-inch circumference pole). The 4-inch circumferential reduction converts to a reduction of 25% in pole strength (i.e., the decayed pole retains 75% of its initial strength).

In general, poles with significant circumferential decay in their outer sapwood should be assessed for possible restoration (reinforcement) with a steel truss or replacement. Poles that are infested with ants or termites can be expected to deteriorate more rapidly than poles not infested, and extra allowance, based on local experience, shall be made for the more rapid rate of deterioration. Remedial treatments can extend the pole life of these severely decayed or infested poles, but such treatments should be considered a temporary stabilizing solution until the ultimate target of pole replacement can be planned and completed.

#### 12.4.3.4 Woodpecker Holes and Similar Damage

Woodpecker damage may consist of holes that go straight into the pole that are made in search of food, or the pole may be hollowed out for nesting purposes. Unless the pole has been hollowed out for nesting, consider the hole as an exposed decay pocket and make appropriate circumference deductions. If the pole has been hollowed out for nesting, consider the entrance hole as an exposed decay pocket and the hollowed out portion as hollow heart, and make appropriate circumference deductions. No deductions are made for woodpecker damage above the top attachment on the pole.

Woodpecker damage is not necessarily indicative of other deterioration in a pole. Woodpeckers have been known to attack freshly set, new poles before the transfer of attachments had been made. In some cases, however, woodpecker damage may be associated with decay or insect attack (usually

carpenter ants). The presence of decay or insect damage may be determined by sounding and/or boring above and below the woodpecker holes.

There are various epoxy filler and wrap products designed to repair woodpecker holes and other damage that creates voids. Such filling materials need to be designed to:

- Bond strongly to wood without shrinking or cracking.
- Flow easily in their uncured state so as to completely fill the void, which is vital in preventing the return behavior of woodpeckers or other animals. The products are usually injected into the void with a plunger to help distribute the filling material into the void spaces.

Wrap products can be used in combination with the filler products where an impregnated fiberglass wrap is used to help retain filling compounds in the voids as well as to protect larger portions of the pole surface from future woodpecker or animal attack. The wrap and filler products can also be used to repair point damage such as may occur from gunshots, trimmers, mowers, and vehicular abrasions.

#### **12.4.4 Critical Pole Section and Required Circumferences**

Determination of whether a pole meets the minimum circumference requirement is based on the actual circumference of sound wood at the critical section, or equivalent circumference of sound wood at the critical section after deductions for defects as described above have been applied.

After determination of the effective pole circumference and strength remaining, the pole inspector has several options to choose from:

- Tag as inspected and found to be sound
- Tag as suspect and note that the pole needs more frequent inspection to monitor deterioration/decay rate of the pole
- Add physical reinforcement to stabilize the pole, e.g., use of steel trusses and wooden stubs
- Do remedial preservative treatments of installed poles to control or stop decay.
- Schedule pole replacement

##### **12.4.4.1 Critical Pole Section**

The critical section is considered as the section of a pole mostly likely to fail because of deterioration by decay or insect damage. In most areas, maximum decay will occur at the groundline or 1 foot below the groundline. In such cases, the groundline is considered the critical section.

If the maximum deterioration occurs at a point above the groundline, the critical section is considered as the groundline, and required circumferences are determined as follows:

- If the section of maximum deterioration is below a point  $\frac{1}{4}$  the distance from the groundline to the top of a pole, the required circumference is that determined from the tables of minimum circumferences at the critical section or the pole inspection rule.
- If the section of maximum deterioration is between the quarter point referred to above and the midpoint of a pole, the required circumference is 10% less than that determined from the tables of minimum circumferences at the critical section or the pole inspection rule, but not less than 14 inches. For example, if the required circumference at the critical section is 30 inches, the circumference required at the higher point is 30 inches minus 3 inches, or 27 inches.
- If the section of maximum deterioration is between the midpoint and the top of the pole, the required circumference is 20% less than that determined from the tables of minimum circumferences at the critical section, but not less than 14 inches. For example, if the required circumference at the critical section is 30 inches, the circumference required at the higher point is 30 inches minus 6 inches, or 24 inches.

When the circumference at the critical section is less than the minimum, as determined from the tables of minimum circumferences at the critical section, or when a pole has been badly weakened by burning, cracking, splintering, or other mechanical damage, replacement shall be recommended. Also, replacement shall be recommended for those poles that, due to deterioration, have a circumference at the critical section above the required minimum, but will further deteriorate so their circumference will be below the minimum by the time of any next scheduled inspection.

Poles shall be reported immediately when they have deteriorated sufficiently because of decay or insect infestation, or have been sufficiently weakened by mechanical damage to be obviously dangerous and could be broken off while climbing or working aloft, or constitute a hazard to the public or employees.

Replacement of defective poles that are not dangerous shall be made as soon as practical on a regular replacement schedule. The proper class and spacing to be recommended for new poles, considering any additional attachments that will be required within an economical period, shall be determined by plant engineering.

Rearrangements of sections of pole line shall be recommended where the inspection indicates the necessity for the replacement of a number of poles and where a change in the location of these and possible adjoining poles will improve or shorten the route.

#### 12.4.4.2 Minimum Circumference

The minimum circumference criteria will be set by the engineering group of the applicable communications company or pole owner based on their internal design criteria and objectives used for their pole line construction.

The general relationship between circumferential reduction and pole strength is determined by the following formula:

Percentage of Retained Strength in Pole =  $[(\text{EC})/(\text{C})]^3 \times 100\%$ , where

**EC** = Equivalent Circumference of sound wood after deductions for defects are made, as per the descriptions in the applicable sections above.

**C** = Initial Circumference of pole.

As a guideline, the NESC recommends pole restoration, rehabilitation, or replacement after the pole strength has reached 67% of its design load (NESC Table 261-1, footnote 2).

The 67% value is based on the anticipated pole loading at the time of initial installation. The loading on the pole may increase or decrease over time as the amount and type of plant attached to the pole changes. Optical fiber cables are lighter than metallic twisted-pair cables, which in turn are lighter than the old lead-sheath cables. As poles become more congested with more cables from competitive communications carriers, over-builds of traditional carriers, additional cabinets and boxes to accommodate new broadband services, then it is not always certain if the overall loading on the pole will increase or decrease. Therefore, as a practical inventory management criteria, 67% of the initial pole strength remains the current best guidance for the minimum allowable criterion.

As noted above, a practical operational strategy to avoid any pole from ever reaching such minimum values is to follow inspection guidelines in Sections 12.5 and 12.6 with the general principles that poles found to have less than 85-90% strength remaining should be monitored on an accelerated inspection schedule, and those found with less than 75-80% strength remaining shall be scheduled for restoration or replacement.

Because of their greater required stability for storm guyed poles, guyed corner poles, and poles part of H-fixture configurations, these poles should be permitted to deteriorate by only 10% (i.e., 90% of strength remaining) before replacement is required.

More stringent criteria may be employed by utilities to help attain increased reliability and resiliency of networks or to help maintain plant in environments or applications that are particularly susceptible to decay or damage.

### 12.4.5 Pole Tags - General

Poles that are considered suspect or defective and are recommended for replacement are marked by special tags. The tags measure 2 to 3 inches on the side, are either square or rectangular, and are placed on both the road and field sides of the pole approximately 6 feet (1.8 m) above the groundline.

Tags are placed so the arrow points to the defective section or area of concern on the pole, i.e., the groundline or the upper portion. Where the pole is defective at both the groundline and the upper portion, a double set of tags are placed with one arrow pointing up and the other arrow pointing down.

### 12.4.6 Tag Descriptions

Three types of tags are commonly used, and examples are shown in [Figure 12-3](#).

- The **A-type** pole tag is usually placed by a communications technician who found a non-critical defect. The A-type tag provides the user with a caution flag to identify climbing hazards, mild surface decay, or other conditions that need to be considered during work on the pole. A pole with an A-type tag can be safely climbed following normal work procedures and does not require additional guying, bracing or reinforcing.
- The **B-type** pole tag, which is a white arrow on a red background, is used to mark poles that have decay found, reduced strength remaining, or a condition that requires further investigation. In the interim, the pole should not be climbed until quantitative analysis or engineering review establish if the pole is safe to climb or needs restoration or replacement.
- The **C-type** pole tag is similar to the B-type pole tag except that an “X” is inscribed in a circle and is imposed on the arrow’s shaft. This tag is intended for marking poles requiring immediate replacement.

**Figure 12-3 A, B, and C Pole Tags**



\*Arrows point toward potential damage or condition of concern. If damage exists at the top and bottom of the pole, two identical tags shall be placed pointing in both directions.

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**Note:** The presence or absence of these pole tags does not act to relieve the licensee of the responsibility for taking appropriate precautions before climbing and/or commencing any work operation on a pole.

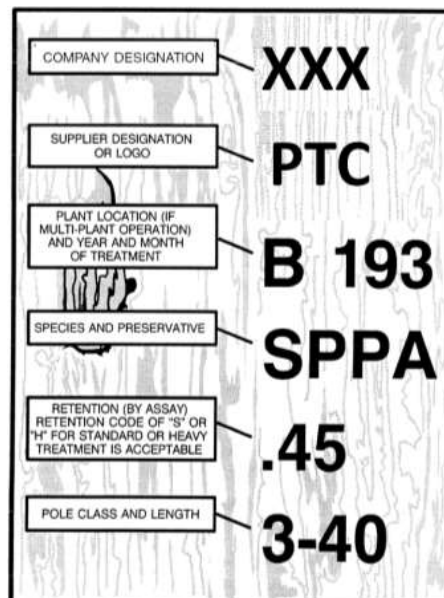
Where a pole appears to be defective and is not tagged, the licensee is requested to report the pole to the communications company and/or pole owner for inspection.

#### 12.4.6.1 Other Pole Markings and Tags

There are other safety markings and informational notices that may be present on the poles in the form of permanent brands, weather resistant labels, and metallic tags that indicate:

- **Pole Brand** (see [Figure 12-4](#) and GR-60) – The position of the brand on the pole can help indicate that the pole has been set to the correct depth. From GR-60, the brand on the face should be located 10 feet from the butt end of the pole for poles up to 55 feet in length, and 14 feet from the butt end for poles 55 feet and longer. The brand shall include the company logo of the pole owner, the pole supplier's code or trademark, the plant location where the pole was preserved and prepared along with the year/month of manufacture, the codes for pole species and preservative, and finally the pole Class and length.

**Figure 12-4 Pole Brand**



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- **Pole identification** numbers are embossed on a rectangular metallic tag or printed on a plastic tag that is screwed or nailed to the pole. Different utilities who share joint use on the pole may each have their own number and tag.
- An **inspection tag** placed by a contract inspection company with an inspection date and company name. This is often a circular metallic tag nailed/screwed low down at around eye height (5-6 feet from near groundline). One will often see plugs lower down nearer to the groundline that are evidence of inspection company drilling into a pole.
- **RF exposure warnings** and notices (see [Section 15.3](#) for a detailed discussion on RF exposure concerns).

## 12.5 Wooden Pole Inspection Programs

The visual pole examination and physical test methods described above should be part of routine work operations during the installation, maintenance, and repair of the aerial communications plant. Over the lifetime of the pole, the pole may be inspected and evaluated a number of times: at the pole factory, on delivery to the user, and at installation as well as during normal work operations.

The integrity of wood poles – that is, their retained strength and structural reliability – underlies the resiliency of power and communication networks. If poles fall, power often goes out until the pole can be replaced. In a digital age, power outages and their duration have large negative impacts on people and the economy. Proper maintenance and inspection practices during the lifetime of the pole can mitigate these impacts and also save utilities money through lower total cost of ownership, extending pole lifetimes, and minimizing potential legal liability.

Structural integrity and, therefore, system resiliency are increasingly challenged by an increase in extreme weather events, as documented by the U.S. Energy Information Agency. The growth in mobile communications services entails more cellular equipment being installed on wood poles revised load calculations. It follows that if wood poles are damaged in an extreme weather event, the wireless telecom services crucial to storm recovery will also be degraded.

### 12.5.1 Structural Reliability

Initial structural criteria are set by the National Electrical Safety Code® (NESC®) with load factors in Section 25 and its Loading District map that establishes baseline standards for pole strength depending on the statistical impacts of ice and wind in various regions combined with strength factors in Section 26 for different pole applications.

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12-22

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**Figure 12-5 Effect of Pole Integrity on Network Resiliency**

| <b>Effects of Pole Integrity on Network Resiliency</b>      |                       |                         |     |
|-------------------------------------------------------------|-----------------------|-------------------------|-----|
| <b>Neighboring Utilities Impacted by the Same Hurricane</b> |                       |                         |     |
|                                                             | <b>Utility "A"</b>    | <b>Utility "B"</b>      |     |
| <b>Pole Inspection Reject Accuracy</b>                      | 98%                   | 30%                     |     |
|                                                             | <b>Actual Numbers</b> | <b>Factored Numbers</b> |     |
| <b>Wood poles replaced</b>                                  | 152                   | 2,790*                  | 18x |
| <b>Number of Peak Outages</b>                               | 95,000                | 487,984*                | 5x  |
| <b>Cost of Restoration</b>                                  | \$20 M                | \$310 M*                | 16x |
| <b>Time of Restoration</b>                                  | 100% in 5 days        | 100% in 13 days         |     |

\* Factored for having 60% more poles

Once installed, structural integrity depends on maintenance. The accompanying schematic illustrates the difference in effectiveness between utility maintenance programs for wood poles, as reported by two adjacent utilities after a hurricane. The advantage of inspection program is clear in terms of the number of poles replaced, number of peak outages, the cost of restoration, and time to restoration. The key difference between the two utilities is that one diligently pursued an inspection and groundline maintenance program.

### 12.5.2 Pole Decay Background

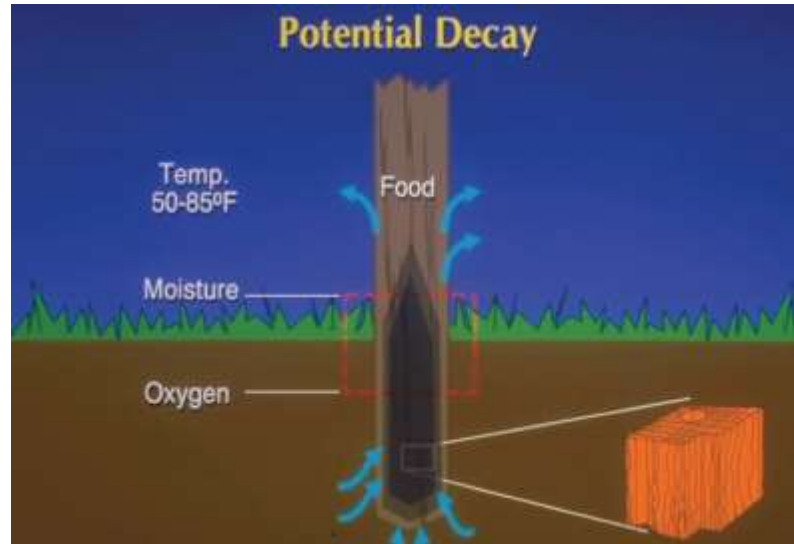
Over time, the wood preservatives are depleted permitting insects to feed on the wood and birds that prey on the insects to damage the pole. The plentiful supply of moisture and oxygen above and 18 inches below the groundline act as catalysts for decay. The same capillary action present in live trees occurs in the bottom of the pole leading to a wicking effect that spreads moisture and decay. As decay proceeds, it reduces pole strength, which over time, can lead to pole failure.

The average pole life expectancy is around 45+ years, but that varies based on location and related climatic factors. The replacement cost of a wood pole varies between urban or rural locations, but the average cost is around \$5,000, including the costs associated with transferring the supply and communications facilities. The average cost of maintenance for a wooden



pole is \$30-\$40 per inspection and treatment, which could occur once per decade. Such a maintenance investment of \$200 cost over four decades can avoid the cost of replacement providing a large ROI. Comparing the capital cost of a wood pole to the cost of maintaining a pole does show that a rather small investment in operations and maintenance can avoid larger capital expenditures.

**Figure 12-6 Potential Decay Pathway in Poles**



Wood pole life is typically measured in decades while the demands for immediate plant repair may compete for the maintenance dollars available. The benefits of methodical inspections over long spans of time are often overlooked in the face of more immediate and urgent demands to repair broken plant and restore service rapidly.

### 12.5.3 Inspection Program – General

As part of some contractual and regulatory agreements, separate pole inspection programs may be implemented as a preventive maintenance action. Such formal pole inspection programs can help identify problem poles and facilitate the initiation of a variety of remedial actions such as re-guying, load balancing, bracing, reinforcement, and preservative enhancement to maximize the lifetime of the pole.

Such a pole inspection and evaluation program will utilize the same visual inspection and testing methodologies that are used by employees before climbing the pole for work operations. Therefore, when employees conduct a

visual inspection and pole test in accordance with the procedures described in [Section 12.1](#), such inspections can be documented and become part of a separate pole inspection program.

The steps discussed in the following subsections should be part of any such pole inspection and testing program:

- [Section 12.5.1](#) and [Section 12.5.2](#) – Training and Pole Remedial Options
- [Section 12.5.3](#) – Visual and Physical Tests
- [Section 12.5.4](#) – Documentation of Results.

An effective inspection program will focus on, and be guided by, criteria such as pole age, pole history, visual assessment, and physical testing, as well as professional judgment. A utility's pole inspection program is typically tracked by its Geographic Information System (GIS). Each utility has its own guidelines for determining inspection priorities. For example, a two-year-old pole is unlikely to need an inspection. If a pole is more than 15-20 years old, it may become a priority for inspection depending on the local climatic or decay zone.

The pole's history may be apparent in the form of a metal inspection tag bearing the date of the prior inspection. A warning tag may document that the prior inspection identified the pole as unclimbable and a candidate for replacement. Otherwise electronic plant databases may need to be reviewed to find out the history of the pole.

The initial visual assessment noted above for operational reasons (i.e., climbing or working on the pole) may also reveal a variety of other issues that require separate action, such as

- A program of vegetation management may be needed to remove vines and creepers from the pole or from along the cable spans between poles, or to prune back branches from adjacent trees.
- Subsidence or undermining of the pole may need to address excessive erosion from groundwater, drainage or soil washouts around the foundation.
- Collapse of the soil immediately around the pole may indicate subsidence caused by water flow, inadequate backfilling during installation of the pole or post-inspection activities, or below ground decay of pole.
- Broken or slack guy wires may need replacement, tightening or re-establishment of grounding/bonding connections.

A regular inspection program can help identify these conditions as well as the more immediate operational problems of obvious pole decay, overloaded pole with too many or too heavy attachments, or leaning poles.

Unless required by regulatory or contractual agreements, the time interval to the first inspection after pole placement and the frequency of subsequent pole inspection is based on a series of factors, including pole design criteria,

work procedures, specific local geographic conditions, available historical pole survey data, and risk assessments. The list below illustrates how these different factors can inter-relate to a pole inspection program and the hazard assessment calculations of a communications company.

- Design factors are covered under product specification criteria including, but not limited to, GR-60, ANSI O5 specifications, AWP Standards, and individual purchasing specifications of the pole owner company (communications or supply).
  - Wood preservative levels prescribed in the industry standards (GR-60 and AWP standards) are based on the decay characteristics of the specific wood species and the expected environmental conditions in the various geographic deployment areas.
- Maintenance procedures and best practices
  - The pole inspection that is completed as part of normal work activities (see [Section 12.1](#) through [Section 12.3](#)) may be documented or recorded in the pole inventory database.
  - Procedural steps may be in place in the pole inventory database to track pole condition, status and defects found during normal work activities.
  - Some companies may have a regular and separate pole inspection program that is designed to visit, inspect, and treat (if necessary) every pole within a set number of years.
- Geography – The natural decay rate of wood poles for a given geographic area is primarily determined by average rainfall, length of growing season, and known distribution of boring insects. However, local historical data on woodpecker or termite damage may also influence the expected pole lifetime and thereby the company's inspection program. The logical division of geographic zones may not necessarily match the operating territory of the communications company or the governmental state boundary.
- Jurisdiction, Regulatory and Legal – Some inspection programs can be required based on other than technical factors:
  - State Government Public Utility Commission (PUC) rules and regulations may specify details of an inspection program, including the frequency
  - Legal requirements based on risk assessment concerns derived from previous legal case histories.

This large range of local factors covers technical, business, economics, regulatory and legal considerations, for which each a company develops its own approach. There is no single pole test frequency or approach that will suffice for all pole owners.

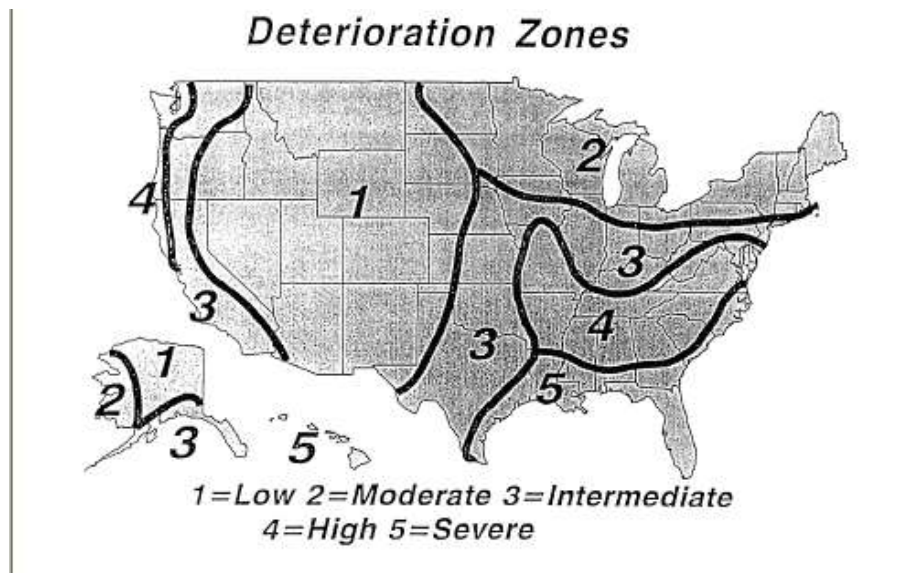
### 12.5.4 Inspection Selection Guidelines

Based on a review of older Bell System Practice documents and the minimum design lifetime of 40 years for poles purchased under Ericsson - NIS generic requirements, the following general guidelines were developed as to which poles are selected for inspection and the frequency of their inspection, with the frequencies primarily determined by their location relative to the known wood deterioration zones.

The details of the inspection program will vary between utilities based all the information discussed above along with their on their own experience, the available workforce, and the regulatory requirements/restraints under which the utility operate (that differ state-by-state) currently being used across the USA,

**Table 12-5 Inspection Selection and Frequency Guidelines**

| Wood Decay Zone | Time of First Inspection and Test after Pole Placement | Frequency of Subsequent Inspection and Testing |
|-----------------|--------------------------------------------------------|------------------------------------------------|
| 1               | 25                                                     | 10-15 years                                    |
| 2               | 20                                                     | 10-15 years                                    |
| 3               | 20                                                     | 10 years                                       |
| 4               | 15                                                     | 10 years                                       |
| 5               | 15                                                     | 8-10 years                                     |



These zones are primarily based on average rainfall, length of growing season, and known distribution of boring insects.

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### 12.5.5 Basic Training for Inspection and Testing

All technicians who need to work on poles or with aerial plant facilities should have basic training in visual inspection, sounding, and prod testing for poles. It is assumed that such training would be part of the regular program at a standardized pole school for technicians who need to work on poles. This training would also include general knowledge of the boring, drilling, and excavation procedures to evaluate the pole, along with the restoration methods that may be required.

This basic pole inspection as part of normal work activities (see [Section 12.1](#) through [Section 12.3](#)) can be documented or recorded in the pole inventory database. If the results of such routine inspections are incorporated into a database or the plant records for that pole, then the more detailed pole inspection, remedial treatment and restoration efforts can be more focused and efficiently directed towards poles that would benefit the most from such attention.

Individuals, or more often now contractors, who are involved in the detailed pole inspection and testing program that require obtaining and analyzing a bore sample or completing a drilling test need specialized skills and require additional training see [Section 12.5.2](#).

### 12.5.6 Specialized Training

In response to regulatory requirements and to optimize the service life of poles and existing facilities, many service providers now use contractors to complete the more detailed and systematic pole inspections. These programs are designed not only to comply with the regulatory rules, but also to maximize the design life of plant for maximum safety, reliability and resiliency of the network. As an alternative to pole replacement, there are various methods to reinforce, restore or refurbish a pole; all are designed to stop or limit further decay. The methods can be used to allow time to evaluate the best engineering choices for an efficient and effective replacement plan for a new pole, redesign of an entire pole line, or possibly relocation of the lines underground.

These employees who are doing the detailed pole inspection, or the contracting company and their employees, need to have detailed and documented training and knowledge for the following activities.

- Recognize early signs of incipient wood decay and deterioration (above and below the groundline) for the different wood species (domestic and foreign) and non-wood poles that are present in the network. This includes recognizing and assessing evidence of, and damage from:

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- Fungi and bacteria
- Insects, woodpeckers, and other animals
- Past grass/brush fires or lightning/electrical arc incidents.
- Boring and drilling procedures to ascertain the quantitative levels of wood decay, if present.
- Excavation procedures around the groundline to permit the necessary inspection without damaging the pole and backfill methods to how best to protect the pole. This includes the proper use of:
  - Surface scrapers to remove soils and detect early evidence of shell rot
  - Chipping tools to remove decayed surface wood.
- The applicable restoration methods that may be used to help prolong the useful lifetime of a pole in cases where signs of decay are found. The methods are designed to stop or limit further decay. The methods can include:
  - Use of reinforcements such as physical support from steel trusses or wooden stubs banded or bolted to the pole in question.
  - The encasement of the pole in concrete or fiberglass to limit further surface decay and to provide physical support to the foundation of the pole.
  - Chemical remedial techniques with the objectives of adding new preservatives to an existing wood pole to stop the decay. These chemical preservatives can be applied through:
    - External bandages impregnated with pastes and wrapped around the pole
    - Internal fumigants forced into the decay pockets and interstices of the wood using pressure techniques
    - Liquid-phase or pastes that are poured or pumped into the internal spaces of the wood similar to the fumigants
    - Rods or pellets with preservatives that are placed in the bottom of a drilled hole that is then plugged. The preservatives in these rods/pellets are designed and selected to diffuse slowly out of the rods and into the wood.

***! CAUTION ! The preservative, fumigant and paste chemicals used in these remedial techniques may require specific work rules (includes OSHA and DOT) and safety equipment (e.g., gloves, etc.) during their use and application along with possible permits from State and Federal EPA regulatory agencies.***



- A consistent means to enter inspection results in a comprehensive electronic database to allow future inspectors to easily and clearly determine any significant change in pole condition.
- One optional inspection criteria whose use may increase in the future is the assessment of the loading on the pole based on the number and type of cables present, pull on the pole, guys and other items that can be visually determined from ground level. Other options for a pole inspector, since they are at the pole location, would be to review the state and condition of guys and anchors attached to the pole (see [Chapter 8](#)), vertical grounding conductors, and any loose attachments. These optional extras are possible but will significantly increase the time (and costs) spent at each pole and the documentation effort.

Early detection of decay or a condition followed by one of the above actions can help prolong the pole life for many years. The pole life can be extended to decades if a program of regular re-inspection and repeated restoration or remedial actions (if necessary) is followed. However, before implementing the restoration and remedial programs noted above, the network provider should request and evaluate studies on the efficacy of any specific remedial method in prolonging the pole lifetime. The benefits and efficacy of these methods needs to be balanced against the needs (and costs) of regulatory compliance, regular re-inspections and pole replacement strategies.

To maximize the return on investment for any pole inspection and testing program, the individuals doing the inspection and testing need to be trained and certified for the work to help ensure quality work is completed and documented (see [Section 12.5.4](#)). Guidelines for such inspection programs and criteria for personnel training can be found in various industry sources, including *M13 - Guidelines for a Pole Maintenance Program* in the American Wood Protection Association (AWPA) Book of Standards. Any inspection program and contract testing company should have internal M&Ps consistent with the best industry guidelines and include the items listed above.

**Note:** There is an American Society of Civil Engineers (ASCE) Wood Pole Design Guide under current development by an ASCE Technical Committee (TC) that shall include a chapter on Inspection, Assessment, Maintenance and Repair of wood pole (see [www.asce.org](http://www.asce.org)).

## 12.5.7 Visual and Physical Tests

The testing strategy involves three levels:

1. Routine pole tests that are part of normal network installation and maintenance activities

2. Deliberate pole tests and evaluation (quantitative) of the degree of decay and pole condition
3. Reinforcement, restoration, or remedial action based on tests in #2 above.

The routine tests (#1 above) are those noted in [Section 12.6.1](#) that are completed during normal network installation and maintenance activities. These tests include:

- The visual inspection process described in [Section 12.1](#), and
- If appropriate, and sounding and prod test as described in [Section 12.3](#).

The deliberate tests (#2 above) follow if there is an indication of decay from the sounding or prod tests. Then a boring or drilling test shall be completed along with a resulting estimate of the degree of decay found (as described in [Section 12.4](#)).

The level #3 actions above are often completed by a contract inspection company and can follow some selection of the various procedures explored in [Section 12.5.2](#) above.

Although these three different activities may be performed by different workers in different companies, it would be useful if the results of these tests would be documented and accumulated together into one database. The pole inspections during routine network activity (level #1) are often not reported or documented unless there is a distinct problem found (decay, damaged or overloaded pole).

As noted above, early detection of decay in a pole or a pole condition can help prolong the pole life for many years. Therefore, it will be useful to have all results of routine and deliberate pole inspection documented in a single accessible database.

### 12.5.8 Documentation

For a formal pole inspection program, documentation<sup>6</sup> will often be needed to meet contractual or regulatory requirements. This section looks at pole inspections of level types #2 and #3 described in [Section 12.5.3](#), where pole decay measurements are made, or some restoration/remedial work is completed.

**Note:** The current trend is to move such documentation to electronic format, although some functional reporting may be required for legal and regulatory reasons and may need to be on paper as well. The trends are more towards electronic databases that are remotely searchable from the field and able to be updated over wireless connections.

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Documentation would include the following:

**Pole Characteristics:**

- Date of pole treatment – determined from pole marking
- Service age of pole – determined from engineering database
- Depth of pole set – determined from the position of Brand mark on the pole, which is typically 10 feet from the butt of the pole
- Size, height and class – measured at site and from pole marking
- Verify pole number and stencil from plant records or engineering database
- Wood species and chemical treatment – from pole marking
- Guy and Anchor (Optional) – is guy straight and tight, insulators in proper place and at appropriate height, anchor rod in proper position, guards in place if required, loose attachments, and so forth as described in Chapters 5, 8 and 9 and elsewhere in this *Blue Book*.

**Document Inspection Result** - The inspection may often be performed in several steps by some combination of internal communications company personnel and contracted pole inspection and rehabilitation company. After the initial assessment during routine network operations that a pole has a problem, an immediate response is warranted to ascertain the applicable tag (as per [Section 12.4.6](#)) that should be placed on the pole. Subsequent drilling investigations and more detailed tests may be required to determine which (if any) rehabilitation method is to be employed.

It has become common to have cyclic test programs (often performed by contract pole inspection companies) where every pole is scheduled for inspection every “X” years based on climate, regulatory requirements, pole age and other operational functional criteria. Within such programs, several of the steps outlined below may be accomplished by the same crew.

**Pass** - The Pole is mechanically sound for expected loads with no indications of decay.

- No A-, B- or C- type tag as per [Section 12.4.6](#) is required.
- If a problem or condition is noted with the pole, but it is still safe to climb for routine work (i.e., an A-type tag problem as per [Section 12.4.6](#)), the pole should be placed on a “*to-be-inspected-soon*” list for an engineering review or for a visit from the contracted pole inspection company.

**Problem Found – Pole Needs More Testing** - The sounding and prod tests indicate pockets of internal decay, but are inconclusive as to the decay extent.

Visual inspection finds a loading condition of concern, or non-standard construction that requires engineering review.

- The pole shall be designated as having a problem requiring further testing, and it should not be climbed unless made-safe by guying, bracing, reinforcement or other means. A “B-type” tag is affixed.
- If the problem is identified as a load condition concern, then further testing may include an engineering review to determine if re-configuration of the aerial plant is necessary or if pole reinforcement is a better option.
- If the problem is identified as a potential decay, the pole shall be further tested (with a boring or drilling examination) to determine the extent of decay (see [Section 12.5.2](#) and Step 3 below).

**Reinforcement -- Restoration – Remedial Action** - If the subsequent testing (see [Section 12.5.2](#)) determines that the extent and thickness of sound wood has been significantly compromised by the underlying decay or damage, the pole should be stabilized with reinforcing stubs and scheduled for replacement.

- A “C-Type” tag is affixed.

**Pole Fails – Replacement** - Sounding and prod tests reveal extensive decay.

- The pole should be stabilized (e.g., reinforced with stub, trusses, braces, or other support) and scheduled for prompt replacement.
- A C-type tag is affixed.

## 12.6 Non-Wood Poles

### 12.6.1 Visual Inspection

The general outline of the visual inspection method outlined in [Section 12.1](#) applies equally well to non-wood poles with the exceptions of evidence of biological damage from fungus, termites, and insects. All non-wood poles must be visually examined before any work operation is begun that involves climbing the pole, placing a ladder against the pole or strand, hanging an aerial platform, riding the strand, or similar procedure where a load is

placed on the pole. While making the visual examination of non-wood poles, the same checklist provided in [Section 12.1](#) is useful with specific attention to the following conditions:

- Bent, loose, or missing pole steps
- Cracks or discolorations associated with stress around pole steps or other attachment points that could result in loosening of pole steps and present a climbing hazard
- Presence of large stones, ground irregularities, debris at the base of the pole, including concrete dust, fiberglass fibers, metal shavings, or splinters
- Evidence of wear or abrasion marks around attachment hardware.

Along with the general criteria noted above and in [Section 12.1](#), each different pole material will have its own particular items of concern to be considered during the visual inspection.

#### **A. Concrete Poles**

- Presence of concrete dust at the base or on the surface of the pole
- Any exposed reinforcing bars or rods
- White or red corrosion rust stains running down the pole from attachment hardware.

#### **B. Steel Poles**

- Peeling paint or discoloration of steel
- Presence of metal shavings at the base of the pole
- Any deviation in straightness of the pole or cross-sectional profile
- White or red corrosion rust stains running down the pole from attachment hardware.

#### **C. Fiberglass Poles**

- Blooming of fibers from the surface of the pole
- Presence of fiberglass or flaked coating at the base of the pole
- Yellowing or discoloration of outer coating indicative of UV degradation
- Any sudden deviation in the straightness of the pole
- Discoloration (stress-whitening) around steps or attachment fittings

- White or red corrosion stains running down the pole from attachment hardware.

A modification of the sounding test can be used to assess the integrity on some non- wood poles. Using a lighter hammer (e.g., 1-lb hammer), the pole is tapped lightly all around the pole base, as high as can be easily reached, or around an area of suspected damage. A suspect area would be where abrasion damage is noticeable or where delamination or cracks are evident.

Tubular (hollow) poles such as steel and fiberglass poles should give a high pitch sound when tapped, but if internal damage has occurred these poles are likely to emit a low shallow sound.

Cracks or kinks in tubular poles (steel or fiberglass) should produce a dull sound rather than a ringing tone.

## 12.7 Informative References for Utility Poles

### 1. GR-60-CORE, *Generic Requirements for Wood Utility Poles*:

- The performance and materials criteria in GR-60 are designed around a minimum pole life of 30 years. Current field data on installed wood poles show that a value of 20-25 years minimum and an average of 35-45 years as a more accurate value with a wide spread of lifetimes between 20 and 50 years depending on climate, wood species, preservative type, and other operational parameters.

### 2. GR-3159-CORE, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles*, includes cross references to:

- Several parts of ANSI C136, *American National Standard for Roadway and Area Lighting*, including C136.20 on Fiber-Reinforced Composite (FRC) Lighting Poles, C136.36 on Aluminum Lighting Poles, and C136.36B on Concrete Lighting Poles
- ASCE-74, *Guidelines for Electrical Transmission Line Structural Loading*
- ASCE-104, *Recommended Practice for Fiber-Reinforced Composite Products for Overhead Utility Line Structures*
- IEEE P751/D2, *IEEE Design Guide for Wood Transmission Structures*, IEEE
- NEMA TT1, *Tapered Tubular Steel Structures*, 1983
- RUS Bulletin 1742E-204, *Guide Specifications for Steel Single Pole and H-Frame Structures*
- RUS Bulletin 1742E-206, *Guide Specifications for Prestressed Concrete Poles and Concrete Pole Structures*

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- TIA/EIA 222G, *Structural Standard for Antenna Supporting Structures and Antennas*.
3. American Wood Protection Association (AWPA) - Book of Standards contains a variety of guidelines and measurement procedures, including:
- U-Documents: User Specification for Treated Wood
  - T- Documents: Processing and Treatment Standard
  - P-Documents: Preservative/Protectant Standards
  - Analysis (A) and Evaluation (E) Standards
  - Miscellaneous (M) Standards, including M13 - *Guidelines for a Pole Maintenance Program*.
4. ANSI O5 Standards - The ASC O5 committee develops standards for wood poles, crossarms, and braces, including:
- O5.1 - *Wood Poles – Specifications and Dimensions*
  - O5.2 - *Structural Glued Laminated Timber for Utility Structures*
  - O5.3 - *Solid Sawn-Wood Crossarms and Braces - Specifications and Dimensions*
  - O5.4 - *Naturally Durable Hardwood Poles - Specifications and Dimensions*
  - O5.6 - *Solid Sawn-Naturally Durable Hardwood Crossarms & Braces - Specifications and Dimensions*.

## 13 Pole Loading and Strength Requirements

The information in this chapter is not intended to be used by the construction staff for the purposes of performing detailed design engineering calculations of the pole line or selection of pole sizes. However, construction personnel will benefit from an understanding of the basic rules and their objectives of NESC pole loading rules so the field staff can better determine when to discuss particular issues with the engineering organizations regarding pole selection guidelines in specific or atypical cases. This chapter includes information on the

- NESC rules defining the loads that utility structures and supported cables or messengers must withstand
- Means of ensuring that the structures and messengers will have adequate strength to support the specified loads
- Standard pole-classification system.

Refer to [Appendix A](#) for further discussion and historical background on pole strength requirements in the NESC.

### 13.1 General

Poles are available in various lengths and are classified by their circumference.

An appropriate pole length is required to provide sufficient height and space to satisfy required clearances of attachments above surfaces and between attachments (cables, wires, and conductors), as described in [Chapter 3](#) of this *Blue Book*.

The pole circumference (size) needs to be sufficient to meet the strength requirements under the various loads to which it may be subjected. Basic strength requirements for utility structures of various materials, including wood poles, are specified in the NESC 2023 Edition.

The power and communications utilities who own and maintain the poles may provide additional requirements, as desired.

The appropriate strength of a wood pole will depend on the

- Number, type, and location (height-on-pole) of attachments for the various conductors, cables, and equipment
- Span length between adjacent poles
- Route geometry in terms of straight segments and corners
- Geographic area which defines the storm conditions and the susceptibility of the pole to decay.

The corresponding design rules for wood poles used in communications

applications, or joint usage by communications and power, are provided in various engineering documents and practices developed within the telecommunications industry. These design rules and practices are consistent with present and past editions of the NESC. It is assumed that the engineering organization of the communications company or the power company, depending upon the ownership of the pole, will provide general guidelines for the construction staff regarding the selection of proper size (strength) poles. Commonly used sizes are stocked locally.

## 13.2 Wood Pole Class Loads (ANSI O5.1)

ANSI O5.1, *American National Standard for Wood Poles – Specifications and Dimensions*, defines wood pole sizes (circumferences) for various lengths depending on the species, and as a function of pole “Class” (size). In the USA, the most widely used species are Southern Pine, Douglas-Fir, and Western Red Cedar.

The pole dimensions (circumference or diameter) are selected such that a particular length and Class pole will have similar load-carrying capability independent of the pole species. Longer poles of the same Class and species have a greater circumference than shorter poles in the same category. The load capacity is based upon the corresponding bending moment at the ground line, which is appropriate for typical distribution pole lengths and utility applications. Poles are assumed to be installed at a depth of ~10% of the pole length plus 2 feet. The resulting height above ground is correspondingly shorter.

[Table 13-1](#) provides the range of Class sizes defined in ANSI O5.1. Typical pole sizes for distribution applications are in the Class 2 to 5 ranges, with Class 3 or 4 (35 to 45 feet long), being the most widely used for communications applications. A common “4 - 40” pole refers to a 40-foot long, Class 4 pole, which has an average load carrying capability of 2,400 lbs (10,680 N), when applied horizontally at a point 2 feet from the tip of the installed vertical pole. Since wood poles are a naturally grown product, as opposed to an engineered material, there is a significant variability within a group of poles of the same Class size, length, and wood species. The NESC accounts for this variability in wood materials by specifying appropriate “strength reduction factors,” as described in [Section 13.4](#).

**Table 13-1 Wood Pole Classification System**

| Wood Pole Class | Horizontal Load (Average Strength in Lbs) |
|-----------------|-------------------------------------------|
| H6              | 11,400                                    |
| H5              | 10,000                                    |
| H4              | 8,700                                     |
| H3              | 7,500                                     |
| H2              | 6,400                                     |
| H1              | 5,400                                     |
| 1               | 4,500                                     |
| 2               | 3,700                                     |
| 3               | 3,000                                     |
| 4               | 2,400                                     |
| 5               | 1,900                                     |
| 6               | 1,500                                     |
| 7               | 1,200                                     |

### 13.3 NESC Storm Loading Requirements

In general, the NESC specifies two types of storm loadings under which power supply and communications utility structures are expected to continue to support the facilities. [Figure 13-1](#) shows the familiar Loading Districts map that has been in the NESC for many editions, albeit with occasional minor modifications.

The country is divided into several districts, as indicated in Figure 1, including Heavy, Medium, and Light for the continental United States, as well as a fourth district for the Warm Islands. The specified ice, varying from  $\frac{1}{2}$  inch in the Heavy district, to  $\frac{1}{4}$  inch in the Medium district (and in the higher elevations in the Warm Islands), to no ice in the Light district, is assumed to be applied radially around the wires and cables, increasing the cross-sectional wind area, as appropriate.

A wind pressure is applied simultaneously to the ice-covered wires, corresponding to 4 pounds per square foot (psf) in the Heavy and Medium (and higher elevations in the Warm Island) districts, or 9 psf in the Light (and lower elevations in the Warm Island) district. The “Light” loading is therefore a misnomer, since it may lead to greater transverse wind loads than that on the ice-covered wires in other districts, especially for larger



diameter conductors or cables.

This “winter storm” loading (combined ice and wind) is the basis of NESC Rule 250B (*Combined Ice and Wind District*) loading represents the basic weather condition to be safely withstood by structures used for typical joint-use applications.

**Figure 13-1 Ice Storm Loading Districts Map – Figure 250-1 from NESC**



The Warm Island Loading District applies to islands located from 0 to 25 degrees latitude, north or south and includes areas such as American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands.

Table 13-2 lists the corresponding ice loads and concurrent wind pressure. Temperatures are also specified since temperature, in combination with the ice and wind loads, will determine the tension in a conductor or messenger.

**Table 13-2 NESC 2023 Edition - Ice Storm Loading Districts per Rule 250B (Table 250-1)**

| Parameter                                       | Loading Districts     |                       |                       |
|-------------------------------------------------|-----------------------|-----------------------|-----------------------|
|                                                 | Heavy                 | Medium                | Light                 |
| Radial thickness of ice (57lb/ft <sup>3</sup> ) | 0.50 inch             | 0.25 inch             | 0 inch                |
| Horizontal wind pressure                        | 4 lbs/ft <sup>2</sup> | 4 lbs/ft <sup>2</sup> | 9 lbs/ft <sup>2</sup> |
| Temperature                                     | 0°F                   | +15°F                 | +30°F                 |

The wind pressures of 4 lbs/ft<sup>2</sup> or 9 lbs/ft<sup>2</sup> in the table are equivalent to a steady 40 mph wind or 59 mph wind blowing on a cable encased in the listed radial thickness of ice.

In addition, the NESC also specifies “summer storm” loadings based upon the ASCE Extreme Wind map contained in the ASCE 7 standard. This map provides higher wind speeds for various areas owing to coastal hurricane and continental winds patterns, based upon 3-second gusts, corresponding to approximately a 50-year return period. The term “extreme wind” implies a rare event, e.g., approximately a 50-year recurrence interval (annual probability of occurrence of 0.02 = 2% probability). It will be seen that the Loading Districts map of [Figure 13-1](#) is not such an “extreme” or rare storm event; i.e., such ice loads may occur significantly more frequently than once every 50 years.

In general, these “Extreme Wind” loads represent major summer-wind loads placed on conductors and support structures that extend more than 60 feet above the surface. The Extreme Wind loading, where applicable, is the basis of NESC Rule 250C. This extreme wind load condition will usually control the required pole strength for applications such as electric power transmission applications where relatively large conductors are placed top of the poles. However, the 60 feet exclusion rule exempts most communications plant and local distribution applications from these Extreme Wind considerations. This includes local electric power distribution, joint power and communications usage, or sole communications lines.

[Figure 13-2](#) illustrates an ice-covered power conductor, and the corresponding weight load (conductor plus ice) and horizontal/transverse wind load on the increased lateral surface. For communications cables supported on a messenger, the ice coating is assumed to engulf both the messenger and cable, as specified in the NESC. The vertical weight loads and the transverse wind loads are transferred to the supporting pole structure. The loads illustrated in [Figure 13-2](#) also results in increased conductor or messenger tension that may impose increased loads on the pole, as indicated in [Figure 13-3](#), depending upon the route geometry and other details.

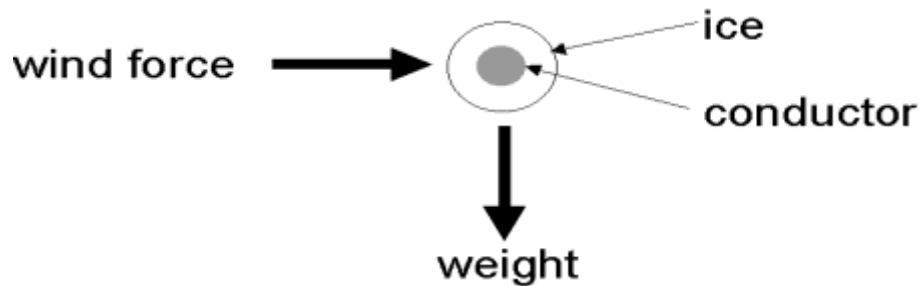
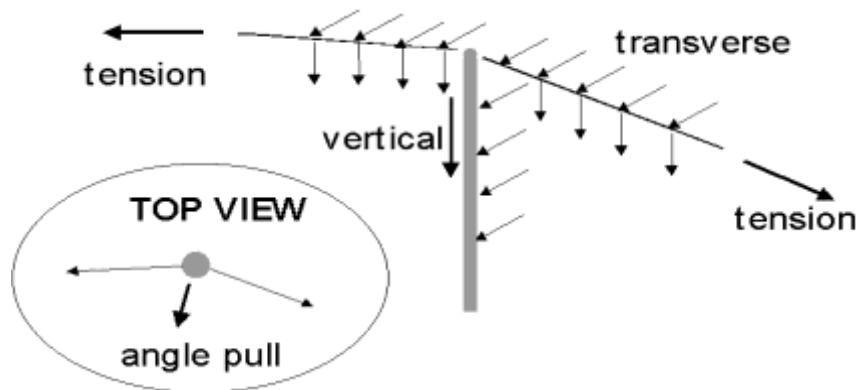
**Figure 13-2 Storm Loads on Cable or Conductors**

Figure 13-3 illustrates the various loads supported by the utility pole or other structure. Thus, the wind force shown in Figure 13-3 is applied in the transverse direction to the line and is transferred to the pole. Similarly, the weight of the ice-covered conductors is applied in the vertical direction and also transferred to the pole.

In addition, there is a horizontal force directly applied to the pole by the wind, as well as the weight of the structure and various hardware mounted directly on the pole, as indicated. The pole line illustrated in Figure 13-3 is deliberately shown to have a corner angle at the pole. In such cases, the messenger or conductor tensions will be unbalanced and there will be a net force (pull) on the pole towards the inside of the corner (unless properly guyed; see Section 13.6). All these loads must be considered acting simultaneously, as appropriate. In general, there will be several conductors or cables attached to a single structure, and the pole must be designed to safely withstand the total of these loads.

**Figure 13-3 Storm Loads Imposed on Poles**

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### 13.4 NESC Wind Maps and Load Factors for 2023

For the 2023 edition, the 2017 NESC wind maps used for both Grade B and Grade C structures were reformatted and updated to using the more recent ASCE 7 data in the form of a 100 year Mean Recurrence Interval (MRI) map for Grade B and a 50 year MRI map for Grade C with a new of load factor 1.0 for both grades.

The load factors are commensurate and consistent with the use of the separate wind maps for Grade B and Grade C construction – see next Section 13.5 and Table 13-3 for discussion on use of load factors.

In addition, a new method is used for calculating the gust response factor for both the structure and the wires more attuned with current ASCE wind data. The primary references for all the new wind maps are the ASCE standards -

- ASCE-7 - *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*
- ASCE-74 - *Guidelines for Electrical Transmission Line Structural Loading*

The ASCE 74 reference is preferred within the electrical and communications industry because of its primary focus on pole and tower line structures of the standard rather than falling under the commentary portion of the ASCE-7. The two MRI map approach is slightly inconvenient from a calculation procedure standpoint, but use of the two maps is a more accurate representation of comparative wind loads for the different construction grades and applications.

These new maps brings the NESC up-to-date with latest wind and gust data with some area wind speeds increased (in the Continental USA) while some hurricane coastal wind speeds decreased. The result of these changes in combination with the different load factors amount to small ( $\pm 5\%$ ) variations in the required pole strength calculated under the 2017 NESC procedures.

Engineering judgement may be necessary for the calculations in selecting an appropriate length, L, for determining the GRF (Gust Response Factor) for lines with spans of unequal length. In special terrain conditions (i.e. mountainous terrain and canyon) where the height of the wire aboveground at mid-span may be substantially higher than at the attachment point, engineering judgement may be used in determining an appropriate value for the wire GRF.

**Note:** More detailed discussions on load and strength calculations in “*Overhead Distribution Lines – Design and Applications*” by Lawrence M. Slavin.

### 13.5 Load Factors and Strength Factors

Since the structure must withstand the loads imposed by the storms, an appropriate condition would appear to be given by the simple condition:

$$\text{Pole Strength} > \text{Storm Loadings}$$

This relationship would require that the strength of the pole be at least as large as the imposed storm loadings, as calculated based upon the NESC rules. However, in order to help ensure that the pole structure will safely and reliably withstand the specified storm loadings, various factors must be applied to the storm loads and nominal structural strength. These factors - the “Load Factor” and “Strength Factor” may be considered to represent design margins and modify the above equation or condition, as follows:

$$\text{Strength Factor} \times \text{Pole Strength} > \text{Load Factor} \times \text{Storm Loadings}$$

The multiplication by the Strength Factor is necessary since the industry-published (nominal) strength of various structural materials (e.g., wood, metal, concrete) are not all specified in a similar manner. The strength of wood poles, for example, is generally understood to be the average strength of a pole in a given class size, as indicated in [Table 13-1](#). In contrast, metal products (steel, etc.) are based upon material strengths specified as minimum values. In general, therefore, it is necessary to provide an appropriate adjustment or “Strength Factor” to the nominal industry-specified strength values to determine an appropriate strength level.

For a conservative, reliable design, this level should be a “minimum” value, which the large majority of structures would exceed. Therefore, Strength Factors are typically less than or equal to 1.0. The NESC specifies a Strength Factor of 1.0 for metal (steel), and a value of either 0.65 or 0.85 for wood (see [Table 13-8](#)), depending upon the “Grade of Construction” (see [Section 13.5](#)).

The Load Factor (see [Table 13-3](#)) represents an amplification factor on the storm loading determined from review of the governing storm maps (e.g., [Figure 13-1](#)). For example, it is recognized that the ice loadings of the historic Loading Districts map are significantly less than those that may be encountered during the active life of the utility line. It is therefore necessary to increase the magnitude of the loads to more closely approximate those corresponding to more severe events, e.g., 50-year storms. Thus, Load Factors as high as 2.5 are applied to the loads determined from the present Loading Districts map, with the precise value dependent upon the Grade of Construction, nature of the loads (vertical, transverse, etc.), and other parameters.

The specific values of the Load and Strength Factors, and the parameters upon which they depend, are actively discussed and continuously under review within the NESC Committee. This is to help ensure consistent and

equitable treatment of various applications and materials.

As indicated above, the wind and ice loads illustrated in [Figure 13-2](#) also increase the tension in the conductor, cable or supporting messenger. The NESC requires that the maximum tension in the messenger during the ice and wind loading conditions in [Table 13-3](#) do not exceed 60% of the rated breaking strength of the messenger.

**Table 13-3 Examples of NESC Load Factors - per NESC Table 253-1**

| Condition (NESC Rule)                     | Load Factors   |              |           |
|-------------------------------------------|----------------|--------------|-----------|
|                                           | Grade B        | Grade C      |           |
|                                           | When Installed | At Crossings | Elsewhere |
| Basic Ice and Wind Loading (Rule 250B)    |                |              |           |
| Vertical Load                             | 1.50           | 1.90         | 1.90      |
| Transverse Load (Wind)                    | 2.50           | 2.20         | 1.75      |
| Extreme Wind Loading (Rule 250C)          | 1.00           | 1.00         | 1.00      |
| Extreme Ice with Wind Loading (Rule 250D) | 1.00           | 1.00         | 1.00      |

For the tall structures where high winds can place significant added loads to the pole, additional *Extreme Wind* or *Extreme Ice* loadings apply (Rules 250C and 250D), along with gust response ( $G_{RF}$ ) considerations and other factors to better simulate possible (but low probability) events for the pole. For these extreme cases, the induced tension due to the wind must not exceed 80% of the rated breaking strength under such conditions. These tension limits are independent of the Grade of Construction.

**Note:** The calculation includes factors dependent on structure height and loading district maps in the NESC that increases the calculated induced tension in the messenger.

## 13.6 Grade of Construction

The NESC strength and loading rules are specified as a function of Grade of Construction (i.e., reliability level), which will determine the appropriate pole Class to withstand wind and ice storms, to meet the basic safety requirements. Three grades of construction are defined by the

NESC relevant to pole lines:

- **Grade B** – The highest grade that typically corresponds to poles located at crossings (e.g., highway, waterways, railroad) and pole lines carrying varying higher voltage power supply). Grade B is not normally required over ordinary streets or highways.
- **Grade C** – A lower grade of construction than Grade B that is widely used for typical distribution power or joint-use (communications and power) pole applications where power lines are not high voltage or open wire (i.e., bare conductors) design.
- **Grade N** – The lowest grade of construction that typically is only used on poles where the sole purpose is to support small size communications plant or service drops applications. The Grade N could also be used across public/private right-of-ways. The permission (waiver in NESC Rule 014) to build to the lower Grade N for emergency or temporary installation should not be abused by leaving such structures unchanged for long periods. Grade N is useful bottom line construction grade for communications and power utilities, particularly in passages and spans across customer property, as well as in some temporary and emergency situations.

There are many combinations of power and communications lines located over each other and over different surfaces for which the required construction grade needs to be determined by reference to Section 24 of the NESC, specifically Rules 241 and 242 in combination with Table 242-1 and its many footnotes. The necessary construction grade can be increased when lines located on different structures cross over one another, and concerns about one line falling into the other requires a more reliable construction grade be used. [Table 13-4](#), which is based on NESC Table 242-1, provides a summary of the required construction grades with a focus on communications plant.



**Table 13-4 Construction Grades for Communications Lines (see Note 4)**

| Lower Level<br>Surface Under Lines<br>or<br>Conductors/Cables | Lines (Conductors & Cables) at Higher Levels |                              |                          |
|---------------------------------------------------------------|----------------------------------------------|------------------------------|--------------------------|
|                                                               | Communications<br>Cables                     | Power Supply Open Conductors |                          |
|                                                               | Including<br>Service Drops                   | Below 750 V                  | Above 750 V              |
| Exclusive Private<br>Rights-of-Way                            | Grade N                                      | Grade N                      | Grade N                  |
| Common or Public<br>Rights-of-Way                             | Grade N                                      | Grade N                      | Grade C or B<br>(Note 1) |
| Railroad tracks, waterways<br>and limited-access<br>highways  | Grade B                                      | Grade B                      | Grade B                  |
| Communications Cables                                         | Grade N<br>(Note 2)                          | Grade N                      | Grade C or B<br>(Note 3) |
| Supply conductors<br>including service drops<br>0 - 750 V     | Grade N                                      | Grade N                      | Grade C or B<br>(Note 1) |
| 750 - 22kV                                                    | Grade C                                      | Grade C                      | Grade C or B<br>(Note 1) |

**Notes:**

- (1) In this case, Grade B is only required for >22 kV open supply conductor.
- (2) The communications lines shall have a grade of construction not less than the highest grade required for any supply conductors or cables located below.
- (3) Grade C can be used if supply power meet Caveats 1, 2, or 3 noted below.
- (4) For construction grade determination under NESC Rule 241 and 242, a supply cable can be designated as either (a) an open conductor, or (b) a supply cable that is shielded or effectively grounded. The NESC Table 242-1 was re-formatted, revised and clarified in the 2023 NESC.

Grade C construction is the most common construction grade used for communications plants since it can be used for a wide range of joint-use structures where supply lines are operating at less than 22kV and if one or more of the following caveats apply:

- Caveat #1 – Lines are located over public/private rights-of-ways, or



- Caveat #2 – The power conductors have voltages less than 5 kV phase-to-phase, or less than 2.9 kV phase-to ground, or
- Caveat #3 – In the case of a power cross with communications lines,
  - the circuit breaker and protection scheme ensures that the supply voltage will be promptly removed by operation of the breaker and de-energizing the power line, and
  - any voltage or current impressed on the communications lines (shield or conductors) does not exceed the safe operating limit of the communications protection devices.
- Caveat #4 - The communications lines are located above the supply power lines or service drops and the supply lines meet Caveat #2 or #3.

The communications circuits that are located below supply conductors shall not affect the construction grade of the supply circuits. On a joint-use structure (communications and power), the required grade is primarily determined by the supply line voltage and its cable/conductor design as well as the underlying surface activity.

Because of the objectives of public safety and high reliability required, Grade B is necessary for railroad, waterway and limited-access highway crossings and on many joint-use structures where high voltage (>22kV) power lines are present. However, even if the overhead supply lines are at voltages above 22kV, Grade C may be used providing Caveat #3 above is met.

Although grade N is permitted for various applications of effectively grounded communications lines and messengers, it is normally reserved for exclusive private rights-of-way, service drops and emergency/temporary installations.

The NESC (Parts 25 and 26) provides specific values for the Load and Strength Factors discussed above for the Grade B and Grade C construction. In general, the NESC Load Factors and/or Strength Factors, and associated rules, provide that Grade B construction for structures or conductors is significantly more robust than Grade C construction. Specific values are not provided for Grade N.

## 13.7 Application

The storm loadings described in [Section 13.3](#), and increased by the appropriate Load Factor, are converted to equivalent lateral loads applied at a point 2 feet from the top of the pole.

**Note:** Equivalent lateral loads are based upon the same ground-line bending moment.

The net load is then compared to the ground-line nominal strength of a selected wood pole of a given Class, as provided in [Table 13-1](#), reduced by the appropriate Strength Factor. If the reduced strength is greater than, or equal to, the factored storm loads, the pole size is sufficient. If not, then a stronger pole (i.e., one with a lower Class number) must be considered.

For small, unguyed corner angles, the contribution of the unbalanced tensions (pull) of the messengers or conductors should be considered as part of the load to be supported by the pole, as illustrated in [Figure 13-3](#). For poles at significant corner angles, the installation of guys is specified (see [Chapter 6](#)). In this case, the effective transverse pull at corners due to the tension in messengers or conductors is balanced by the guys installed to pull in the opposite transverse direction. The strength of the guying system (guy wires, hardware, anchors, etc.) is selected to be compatible with the magnitude of the unbalanced tension loads. In this case, the NESC only requires that the pole strength be sufficient at the point of attachment of the guy, e.g., without regard to ground-line bending moment/loads and strength.

However, for the purposes of selecting an appropriate minimum pole size, a conservative design practice would be to hypothetically assume the absence of both the required guying and the otherwise unbalanced corner pull forces, and select the pole based upon the corresponding equivalent lateral wind loads (2 feet from the top of the pole) and ground-line strength, as before. The required guying and associated procedures would then be applied to the selected pole. In addition, the significant downward vertical load on the pole applied by the guys must now be considered. These large loads, in combination with other vertical loads (ice-covered conductors, transformers, etc.), may lead to pole failure due to column buckling. Therefore, it must also be verified that the size and corresponding rigidity and buckling strength of the pole are sufficient to withstand the resulting vertical loads.

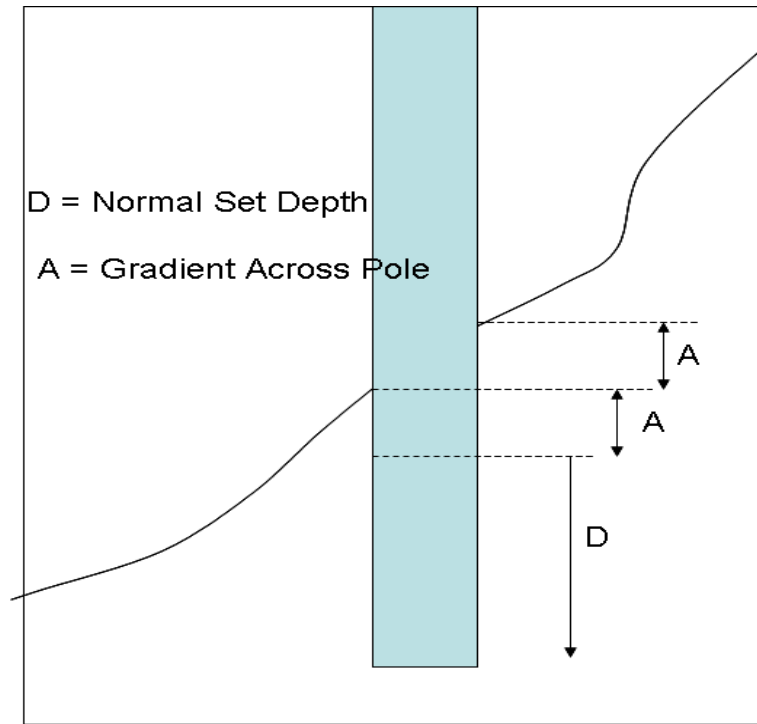
## 13.8 Depth of Set

[Table 13-5](#) provides general guidance on depth of set for the usual pole lengths owned by communications companies. Although communications companies will attach to taller poles under Joint-Use Agreements (JUAs), the taller poles are usually owned and maintained by power supply companies who require the additional height for high voltage lines.

For unguyed poles with significant corner pulls, and/or depending upon the magnitude of the transverse storm loading, the pole depth may have to be increased to greater than the nominal burial depth otherwise assumed to be sufficient ([Section 13.2](#)). The increased depth, as necessary, will limit tilting of the pole during storms. The recommended pole depth also depends upon the depth of the frost level. Deeper or greater frost levels will require commensurate greater pole depth.

**Table 13-5 Depth of Setting Pole**

| Length of Pole (ft)                                                                                                                                                                                                                                                              | Depth of Set (ft-in) |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------|
|                                                                                                                                                                                                                                                                                  | Firm Earth           | Solid Rock |
| 30                                                                                                                                                                                                                                                                               | 5-6                  | 3-5        |
| 35-40                                                                                                                                                                                                                                                                            | 6-0                  | 4-0        |
| 45                                                                                                                                                                                                                                                                               | 6-6                  | 4-6        |
| 50                                                                                                                                                                                                                                                                               | 7-0                  | 4-6        |
| 55                                                                                                                                                                                                                                                                               | 7-6                  | 5-0        |
| 60                                                                                                                                                                                                                                                                               | 8-0                  | 5-0        |
| <b>Note 1:</b> In sloping ground, increase the burial depth from the standard depth (D) to a minimum depth of A+D, where A is the change in ground level across the slope (gradient). See the figure below.                                                                      |                      |            |
| <b>Note 2:</b> Unguyed corners and dead-end poles should be set at greater-than-normal depth to limit tilting. For example, a corner pull of 20 feet on a 50-foot pole would increase basic depth from 7 to 8 feet.                                                              |                      |            |
| <b>Note 3:</b> Frost level will also increase pole set depth requirements for cases like an unguyed corner. For example, the corner pull of 20 feet on a 50-foot pole in soil with a frost depth of 3 feet would increase the basic burial depth from 7 feet to 8 feet 6 inches. |                      |            |



The NESC primary focus is on strength requirements as based upon storm loadings. However, to a lesser degree, significant loads may be imposed upon the pole under “everyday” conditions. Such conditions could include loads due to incorrectly tensioned strand or guys at corners, or overloaded crossarms. In such cases, it may be necessary to increase the pole size (strength) to allow the pole to withstand the degrading effects of such long-term loads on the strength of the wood pole or reconfigure the attached plant to remove the problem loads.

### 13.9 Conditions of Potential Concern

The loads imposed on the pole depend upon the storm loadings and other considerations described above. The required pole strength will depend on the

- Magnitude of the storm conditions (ice thickness, wind pressure)
- Number, size (diameter) and height of the attachments (cables, conductors, etc.)
- Span Length
- Route geometry (e.g., straight or offset pulls).

For example, for a straight route and a given set and arrangement of attachments, the storm load imposed on a pole will be directly proportional to the span length. Thus, a span length of 200 feet will result in an imposed

storm and required pole strength of twice that of a span of only 100 feet.

The tension that is induced in a messenger strand supporting a cable is also dependent upon the ice and wind load on the wires (Figure 13-2), the cable size, and the span length. In general, increased ice load, larger diameter of the cable/ messenger bundle, and longer span length will result in greater induced tension.

Excessive over-lashing of cable(s) on an existing strand may result in a messenger tension, under storm conditions, in excess of the 60% limit relative to its rated breaking strength.

The design or engineering organization of a communications company will provide general guidelines for the construction staff regarding the selection of proper size (strength) poles and messenger usage. However, situations that appear to require special attention, including a potentially overloaded new or unbalanced loading on an existing pole or messenger, should be brought to the attention of the engineering organization for re-consideration or possible upgrading.

Engineering judgments are also required because of other effects such as those described in Section 13.4 as well as (a) the loading effect of the weight of ice on the structure is dwarfed by the weight of ice that can gather on lines (cable and wires), and (b) for given situations where a point load in the span occurs (e.g., strand mounted equipment at one point in the span), it is not accurate to distribute the load across the entire span for the sake of a simpler engineering calculation. In case (b) above with a strand mounted equipment, it is useful to place the equipment close to pole (e.g., within 2-4 feet) to minimize added tension and minimize sag increases across the span.

The strength and loading calculations often revolve around different perspectives from designers constructing (a) large high voltage transmission towers (tall 3 or 4 legged metal structures) with regular long spans that may cross deep valleys, and those that construct and design (b) distribution wooden, steel or fiberglass poles with multiple attachments, unequal spans, service drops and lines radiating out in various directions that require guys to maintain balance on structures and may be found in densely populated urban and suburban areas. The latter group will more often be joint-use with medium and low voltage supply lines, several communications carriers and other attached equipment.

## **13.10 Pole Loading Calculations and Proposed Guidelines**

### **13.10.1 Background and General Review**

The ubiquitous utility poles seen throughout the country represent the most convenient means of adding or upgrading new communications facilities, including both wireline and wireless services. However, the installations must comply with accepted safety rules and government regulations,

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including that of the National Electrical Safety Code (NESC), which is the primary focus of discussion and guidelines in this *Blue Book*. The General Order 95 (GO95) that applies in California is not specifically addressed herein, although the similar clearance, loading and strength considerations need to be addressed for those areas.

As part of an application process, the potential attacher would conduct a field visit to survey the proposed sites to determine the available space and possible problems in attempting to mount its facilities, cables and/or equipment on the poles of interest. The issues that most often inhibit timely installations are those related to clearances and available pole strength.

The NESC safety code specifies minimum clearances of overhead lines from surfaces below, and from each other, with relatively large separations between those facilities in the “communications space” from those in the “supply space”, including electric power lines, above. Clearances are specified between the individual supply lines, and also between the individual communication lines, typically at a spacing of 12-inches between cables at the pole. Compliance with these separation distances is often a challenge, possibly requiring existing facilities to be moved up or down the pole, as part of a “make-ready” process, or, in some cases, replacing the existing pole by a taller pole. While the solution of such clearance problems may not be easy, and may sometimes be expensive, the evaluation of the situation is generally clear. These NESC clearances along the spans are generally required to be satisfied at the specified “worst-case” (temperature, ice, ...) conditions, which may require determination of the corresponding sags for cables and wires to adjust the sag and maintain adequate separation to adjacent messenger strands.

The related strength issues, however, are often not so readily evaluated, but there are various alternatives for demonstrating the necessary compliance. Potential attachers of communications facilities fall into two general categories – ILECs (such as Verizon, AT&T, ...) and third-party attachers (such as Cable TV providers, wireless operators, ...). As third-parties, who do not own or jointly-own poles, they are sometimes considered as “tenants”, or “licensees”, rather than “joint-users”, for which different procedures and privileges may apply. For example, the pole owner, even if not the ILEC, will generally reserve the lowest viable position(s) on the pole, consistent with meeting the NESC (or possibly DOT) ground clearances, for the ILEC, and sometimes the lowest two positions, at the 12-inch spacing indicated in the NESC. In such joint-use situations, the ILEC may also have responsibility for managing the communications space, including applications by the third-parties. It is therefore possible that the ILECs may follow, or allow, different methods of ensuring compliance with the strength rules of the NESC than would the supply company that may own, or jointly own, the pole.

The transverse wind loads (Section 13.3), applied to the (ice-covered) wires,

and transferred to the pole at their respective heights of attachment at the pole, are the most important consideration regarding the required strength of the pole for typical tangent lines (no line angle between poles). These loads apply a large bending moment at the base (ground line) of the pole, equal to the magnitude of the force(s) multiplied by the attachment height(s), the sum of which may be compared to the allowable ground line (GL) bending moment – or strength – of the pole, as the typical parameter of interest for the widely used wood poles.

While the wind loads on the wires are usually the dominant factor in cases of concern (i.e., several wires and cables, and long spans), the effect of the wind loads on other supported attachments, and the pole itself, should also be included. It is noted that, in spite of the common tendency to think of the weights of the attachments as an important factor affecting the required strength of the pole, these loads typically represent only a minor contribution to the bending moment of interest, due to their relatively low eccentricity compared to the bending moment corresponding to horizontal wind loads applied at the attachment heights. The weights, however, do become important for poles with line angles, for which the wire tensions, which depend upon the imposed weights as well as wind load, are usually the major contributor to the GL bending moment, typically requiring guys to resist the unbalanced tensions and provide the necessary support.

The pole strength is characterized by the ultimate (breaking) bending moment, or equivalent transverse force applied near (two feet from) the top of the pole, or the corresponding peak fiber strength, for the prevalent naturally grown wood poles, specified via the ANSI O5.1 Standard. These strength values are understood to be the average strengths for each category (Class size) of pole. The NESC, however, applies an effective safety factor in determining the appropriate strength, depending on the application, or required “grade of construction”. Thus, a “load factor” (typically  $\geq 1$ ) is applied to the load(s), and a “strength factor” (typically  $\leq 1$ ) is applied to the nominal strength, with the following resulting requirement:

$$\text{strength factor} \times \text{strength} \geq \text{effect of (load factors} \times \text{loads)}$$

Although the NESC does not use the explicit term “safety factor”, the ratio of a load factor to the strength factor corresponds to an effective safety factor. Thus, for typical joint-use wood distribution poles, primarily subject to transverse wind loads, the ratio, or safety factor, is approximately 2-to-1, based on a load factor of 1.75 and a strength factor of 0.85.

The traditional method for ensuring compliance with the NESC is provided in the Bell System or AT&T Practices, as reflected in the *Outside Plant Engineering Handbook* (900-200-318, Lucent Technologies, October 1996). While satisfactory for addressing the status of most wood poles, these procedures have been largely superseded by the introduction of sophisticated software tools, utilized by the utility or an interested party, possibly via a contracted consulting or engineering firm specializing in their use and



application. These software systems are capable of providing a detailed pole loading analysis (PLA), including for complicated configurations.

However, there are a convenient practical methods to determine compliance such as to compare the new application under consideration including any proposed attachments, to other similar configurations known to comply. These reference configurations may be existing installations that have been previously subject to a formal strength/loading analysis, or may possibly represent “standard” cases (specified pole size, span length, typical attachments, ...) known to be in compliance. Similarly, for an existing pole line with similar attachments, or proposed set of attachments, to the pole line, it would only be necessary to analyze the most heavily loaded, and/or weakest, pole (e.g., longest span or smallest weakest Class pole,...) along the line, to confirm compliance for all the similar configurations along the pole line.

These alternative means can be especially useful in the cases of typical distribution lines arranged along a tangent configuration (no line angle), for which the transverse wind loads tend to be the predominate factor. Thus, using the principles described above, the approximate status of the pole may be evaluated using a spreadsheet, with no other special software requirements, resulting in a measure of the “percent utilization” of the pole, and, conversely, the remaining margin available for additional future attachments. Also, if the remaining margin for a pole is known, from a PLA analysis for example, the impact of a proposed attachment may often be readily evaluated and compared to the available margin, without the need to completely re-evaluate the pole including all the existing and proposed attachments.

However, if the new proposed attachment is more than a minor hardware or equipment addition, or a simple overlashing event, then good industry practice is to perform a PLA study to establish a new baseline for that pole or as a representative or reference pole. Such attachments warranting a new PLA study could include circumstances of adding a new messenger strand and its accompanying cable, cases of particularly long spans between poles, attachments to a known weak or low strength pole, or considering placement of numerous attachments on a single pole.

An excellent resource for answers on strength and loading questions can be found in *Overhead Distribution Lines -- Design and Applications*, by Lawrence M. Slavin published by Wiley-IEEE with several examples for pole scenarios in Section 10.5 and Appendices of that book. Examples are provided for (guyed) pole configurations including line angles, in which case wire tensions must be considered. The determination of such tensions under specified storm load conditions is non-trivial, but a convenient, generally conservative practice is to use the maximum allowable tension, corresponding to 60% of the rated breaking strength (RBS), where experience, or existing guidelines, indicates this limit is not exceeded.



Alternatively, for communications lines, tensions under storm conditions may be determined using an available software packages such as SpanMaster®, a user-friendly software tool provided as a courtesy to the industry through Commscope, capable of determining sags and tensions of communication lines under NESC storm conditions. The theoretical basis and mathematical solution for such cases, as well as the relevant physical characteristics of the messengers, is also provided in the Wiley-IEEE publication.

### 13.10.2 Overlashing Case Scenario

If there is a need for a communications company to upgrade or supplement its network by means of adding a new cable (powering or communications backhaul), there are basically two options; i.e., adding a new messenger to support the new cable, or to lash (“overlash”) the new cable to an existing messenger, owned by the same company. In addition to operational efficiency, the major advantages to the latter procedure include space savings and reduced loads on the pole. It is therefore not surprising that this practice has been widely adopted as already noted in Section 4.8 (Strand chapter) and being consistent with the recommendation in Section 27.1 for optical fiber cables which states:

“Where applicable, consider using overlash construction methods rather than placing new strand.”

Because of the benefits of this practice in expanding the availability of broadband access in the United States, the FCC has ruled (47 CFR § 1.1415 Overlashing) that a utility shall not require prior approval for:

- (1) An existing attacher that overlashes its existing wires on a pole; or
- (2) For third party overlashing of an existing attachment that is conducted with the permission of an existing attacher.

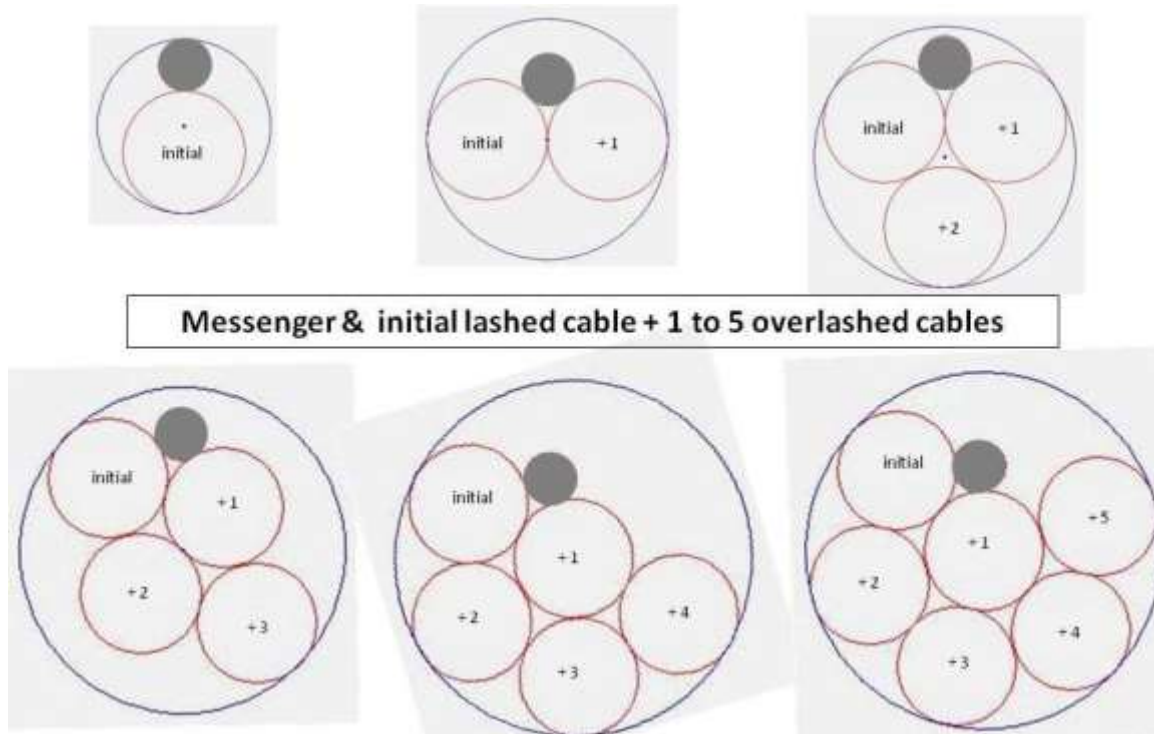
The FCC does, however, allow an exception if – at its own cost – the utility “determines that an overlash would create a capacity, safety, reliability, or engineering issue”, for which it must provide specific documentation. Thus, in general, the FCC ruling places the primary responsibility for ensuring the safety and performance of the pole and related facilities on the party performing the overlash: *“A party that engages in overlashing is responsible for its own equipment and shall ensure that it complies with reasonable safety, reliability, and engineering practices.”*

The overlash case provides a good illustration of the complexities that can develop in determining strength and loading requirements for poles as well as the sag and tension calculations for the supporting strand and guys.

The sizes (dimensions and linear weight) of the optical fiber or coaxial cables that are likely to be added to an existing strand are relatively low compared

to the larger multi-pair metallic copper pair traditional telephony cables. Figure 13-4, for example, illustrates the resulting bundle geometry for as many as five additional overlashed cables on a single messenger. While the bundle size and weight obviously tend to increase with each cable addition, the primary load on the pole, for tangent construction, is that due to the magnitude of the transverse wind load(s) corresponding to the ice-covered-diameter (as appropriate) of the circumscribed circle of each strand.

**Figure 13-4 Geometry of Overlashed Cable Bundles**



The overall dimension (diameter) of the bundle will determine the magnitude of the wind loading and ice accumulation effects of the addition of several cables to a bundle. That total bundle size does not increase significantly between adding the 3rd, 4th and 5th cable as shown in Figure 13-4 above.

The net effect of this load on a single bundle of several cables is much less than that of several attachments, each comprising a single cable on its own strand, especially under ice loading. In fact, depending upon the nesting configurations, the incremental wind load for an individual overlashed cable, may be negligible, such as the addition of the fifth overlashed cable in the above Figure 13-4. In such cases, it is quite possible that the results of a PLA may appear to indicate that a pole is *less* heavily loaded than that

recorded prior to the addition, depending upon the assumptions and methodology (software, options, ...) used in the different analyses, including the consideration of the details of the multitude of attachments, as well as the estimated overlashed bundle size.

While the additional weight of the cable(s), and resulting increased ice loading, will increase the peak tension under storm conditions, the incremental, as well as cumulative, effects are also relatively low, and, for reasonable span lengths, the tension is likely to remain well within the recommended 60% limit prescribed in the NESC, with the possible exception of very long spans and/or in the case of the addition of large copper cables.

Increased tensions will impose unbalanced loads at poles with line angles, which must be supported by the existing guying system. The incremental tensions are much less than that which would result from the addition of a separate messenger strand for the required cable addition. Because of the typically conservative design used for most guy/anchor systems, the existing support system of poles, guys, and strands will usually be sufficient.

The ability to utilize existing pole space is the most obvious benefit to the practice of overlashing, since it avoids the need to place a new messenger, at the nominal 12-inch spacing on what is often already crowded and congested pole. Although the overlashed cable may lead to reduced clearances (e.g., between communication lines), this may be compensated by adjusting the sags and tensions, as appropriate, or the possible use of spacers to maintain the required separation between lines.

**Note:** The quantitative effects of overlashing, regarding both loads and clearances, are more fully discussed in *Overhead Distribution Lines -- Design and Applications* by Lawrence M. Slavin (*IEEE Press-Wiley*). Also see Section 4.7 for a discussion on strand tension.

### 13.10.3 Guidelines for Overlashing – Tangent, Angle and Dead End Poles

#### *CASE #1 - Tangent Pole Lines (Straight Line) that does not require Guying*

A practical, generally conservative, guideline for jointly used tangent (unguyed) structures is provided in Table 13-6 below, in which the number of overlashed cables refers to the cumulative number of individual communication cables, across all communications companies – including third parties and the ILEC (incumbent local exchange carrier), which may be a pole owner (or co-owner) – that have been installed since the last full PLA was performed, and for which the results are available.

The pole is assumed to be a typically configured joint-use pole, with the electric supply facilities installed in the uppermost portion of the pole and the communications facilities mounted lower on the structure.

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Table 13-6 provides the required remaining margin (availability) for the pole, in order to avoid the necessity of performing a formal pole loading analysis, as a function of the total (cumulative) number of overlashed cables, for all parties in the communications space, since the previous PLA performed on the pole. For example, the 4<sup>th</sup> row shows that one can overlash 7 new cables in the medium loading district if the pole has at least 30% of strength remaining or conversely stated if the pole usage is less than 70% of its available strength or capacity. In the event that the existing margin is not sufficient, then it is recommended that a formal PLA analysis be completed and the results used to determine the new margin and the next occasion on which such an analysis is required, using the same general guidelines.

**Table 13-6 Remaining Pole Margin – Unguyed Tangent Lines**

| <b>Remaining Pole Margin (Based on Allowable Pole Load)<br/>Required to Avoid PLA (Unguyed Tangent Lines)</b> |                                |                                |                                |
|---------------------------------------------------------------------------------------------------------------|--------------------------------|--------------------------------|--------------------------------|
| <b>Cumulative Number of Overlashed Cables Since Previous Pole Load Analysis</b>                               | <b>Heavy Loading District</b>  | <b>Medium Loading District</b> | <b>Light Loading District</b>  |
| 1                                                                                                             | ≥ 10% margin<br>(≤ 90% usage)  | ≥ 10% margin<br>(≤ 90% usage)  | ≥ 15% margin<br>(≤ 85% usage)  |
| 3                                                                                                             | ≥ 15% margin<br>(≤ 85% usage)  | ≥ 20% margin<br>(≤ 80% usage)  | ≥ 25% margin<br>(≤ 75% usage)  |
| 5                                                                                                             | ≥ 20% margin<br>(≤ 80% usage)  | ≥ 25% margin<br>(≤ 75% usage)  | ≥ 35% margin<br>(≤ 65% usage)  |
| 7                                                                                                             | ≥ 25% margin<br>(≤ 75% usage)  | ≥ 30% margin<br>(≤ 70% usage)  | ≥ 40% margin<br>(≤ 60% usage)  |
| 9                                                                                                             | ≥ 30% margin<br>(≤ 70% usage)  | ≥ 35% margin<br>(≤ 65% usage)  | ≥ 45% margin<br>(≤ 55% usage)  |
| 11                                                                                                            | ≥ 30% margin<br>(≤ 70% usage)  | ≥ 35% margin<br>(≤ 65% usage)  | ≥ 45% margin<br>(≤ 55% usage)  |
| ≥ 12                                                                                                          | Recommend new PLA be performed | Recommend new PLA be performed | Recommend new PLA be performed |

The quantitative values in the guideline reflect the small incremental loads for each overlashing event but allows for a potentially greater effect for the first overlashing event, which is generally more significant than subsequent overlashings, which tend to diminish in significance, and also in recognition that a highly utilized pole requires caution when adding more attachments.

These guidelines or recommendations consider various factors such as:

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- a) The presence of supply lines at the upper portion of the joint-use pole contribute significantly to the total loading (GL bending moment).
- b) The criteria for requiring a PLA depends on loading district because the effect of the incremental increase in bundle diameter is diluted by the presence of radial ice, if any, and in comparison to the ice-covered power conductors mounted higher on the pole.
- c) It is conservatively assumed that only two, relatively small, supply conductors are present, and the communications lines are mounted relatively high on the pole, at two-thirds the height of the supply wires, and any load contribution due to the pole itself, or pole-mounted equipment, is small and can be ignored.
- d) While it is also assumed that a minimum of two communications lines (messengers) are present for any pole that may be of concern for potential overload, the likely presence of a greater number will reduce the impact of each overloading event.
- e) The magnitudes of the incremental effects of the additional cables are derived from the geometry illustrated in Figure 13-4, for similar sized cables. However, it is more than likely that cables overlashed to an existing line will be no larger in size, and possibly smaller, than the existing cables, as fiber (or coaxial) cables are added to provide increased bandwidth for supporting improved technologies and/or improved services.

The overloading events are considered to comprise the addition of a cable, but with no significant increase in (transverse wind) loading associated with the simultaneous possible addition or replacement of strand-mounted equipment. In other cases, where there is an increase in strand-mounted equipment, located close to the pole, this should be considered as an additional overlap for the purpose of determining if a PLA is required.

Although the guidelines are intended to apply to the large majority of practical applications, there may be unusual cases in which special consideration may be required. For example, a joint-use pole containing an unusually long span of only two very small supply conductors, and a single communications line mounted relatively high on the pole, in combination with a relatively weak Class pole, may be in jeopardy of being overloaded, and for which the above guidelines may not be sufficient and a new full PLA is warranted.

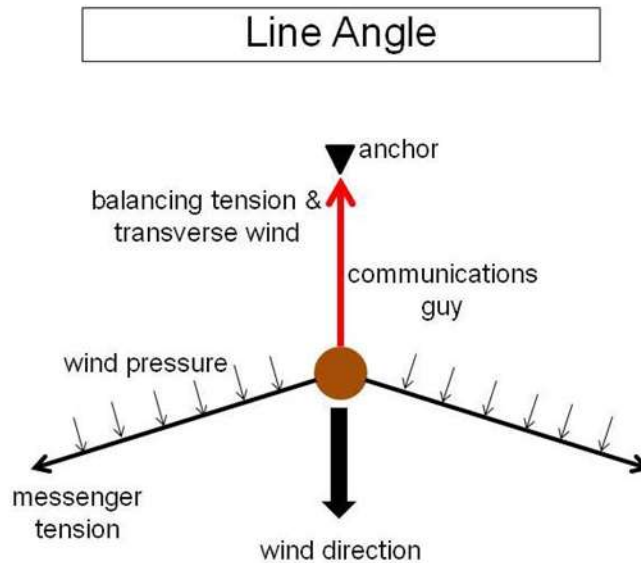
***CASE #2 – Pole Line is Angled and Poles Requires Guys***

Whereas the above guidelines are applicable for (unguyed) tangent construction, there are additional strength considerations required for guyed poles located at line angles or dead-ends to evaluate the capability (i.e., strength) of the communications guy system to support the associated unbalanced loads acting on the pole. The guy wires (and anchors) at line angles must withstand the peak (storm) tensile loads imposed on the wood pole by the messengers, in addition to the transverse wind loads applied to the conductors, acting in concert – i.e., the wind forces blowing in a direction tending to push the supported conductors away from the guy anchor, as illustrated in Figure 13-5. For wood poles, the guys are required to withstand the full (vector) sum of these unbalanced loads.

In general, except for very low line angles, the wire strand (messenger) tensions are the dominant factor for determining the guy loads, for which the values in Table 13-7 are conservative. However, for any line angle, for the case of wind blowing in the opposite direction from that shown in Figure 13-5, the transverse wind load on the conductors is the critical consideration. In this case, the guys are inactive and the support of messengers is conveniently ignored, although the messenger strands are likely to provide significant support for the original and added loads in that direction. The criteria of Table 13-6 are therefore again considered to be relevant for this application, in addition to verifying the status of the guy system. It is assumed that the pole is properly guyed, with separate guys attached to the power level and communications level, with the communications guys essentially managing the unbalanced loads imposed by the communications lines.

For design procedures, including the PLA, for poles at significant line angles, for which the tensions dominate the wind loads, and the peak messenger tensions have been assumed to be the limiting value of 60% of the RBS, it is only necessary to verify that the tensions remain within this limit, as discussed above. For the more general case in which the tensions are evaluated as a function of the storm loading, the margins in Table 13-7 are applicable to the communications guy system, and the margins in Table 13-6 are applicable to the pole strength, considering the opposite direction of the wind as shown in Figure 13-5.



**Figure 13-5 Load Analysis on Guyed Line Angle Pole**

The required margins in Table 13-7 reflect the incremental loads of the wire tensions, as well as transverse wind, caused by the overlashed cables on any or all of the several ( $m$ ) communications messengers, resulting in greater unbalanced loads to be supported by the guy(s) attached to the communications space. As indicated, for multiple messengers in the communications space, the required margin remains the same for that number of overlashed cables, which is a convenient, guideline. For example, for three strand messengers ( $m = 3$ ) on a pole in the medium loading district, a detailed load analysis is not necessary for as many as six ( $2m = 6$ ) overlashed cables, providing a margin of at least 30% of available strength is available for the critical guy; i.e., the communications guy with the least available margin.

The values indicated are generally conservative, allowing for the multiple overlashings to be distributed across all of the messengers, as opposed to the diminishing effects of cumulative additions to the same messenger. The values also allow for the unlikely possibility that the unbalanced load is primarily due to the transverse wind and not the wire tension which results in lower incremental loads. The same criteria in Table 13-7 apply to the corresponding anchor(s). If a common anchor is used for both the supply and communications lines, the same available percent available margin requirements apply to the single anchor, which is again conservative since the percent usage includes the load from the supply lines.

**Table 13-7 Remaining Pole Margin – Guyed Poles at Line Angles**

| <b>Remaining Guy Margin (Based on Allowable Guy Load) Required to Avoid PLA<br/>(Guyed Poles at Line Angles or Corner Poles)<br/>(m = number of communications messengers)</b> |                                   |                                    |                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| <b>Total Number of<br/>Overlashed Cables Since<br/>Previous Pole Load<br/>Analysis</b>                                                                                         | <b>Heavy Loading<br/>District</b> | <b>Medium Loading<br/>District</b> | <b>Light Loading<br/>District</b> |
| 1 to m                                                                                                                                                                         | ≥ 20% margin<br>(≤ 80% usage)     | ≥ 25% margin<br>(≤ 75% usage)      | ≥ 30% margin<br>(≤ 70% usage)     |
| m+1 to 2m                                                                                                                                                                      | ≥ 25% margin<br>(≤ 75% usage)     | ≥ 30% margin<br>(≤ 70% usage)      | ≥ 40% margin<br>(≤ 60% usage)     |
| 2m+1 to 3m                                                                                                                                                                     | ≥ 35% margin<br>(≤ 65% usage)     | ≥ 40% margin<br>(≤ 60% usage)      | ≥ 50% margin<br>(≤ 50% usage)     |
| 3m+1 to 4m                                                                                                                                                                     | ≥ 40% margin<br>(≤ 60% usage)     | ≥ 45% margin<br>(≤ 55% usage)      | ≥ 55% margin<br>(≤ 45% usage)     |
| >4m                                                                                                                                                                            | recommend new<br>PLA be performed | recommend new<br>PLA be performed  | recommend new PLA<br>be performed |

While the criteria in Table 13-7 are intended to apply to guyed poles at line angles, they may also be conveniently applied to un-guyed applications at small line angles (e.g., a pull of 2 – 3 feet on a pole, or a total line angle of approximately 3 degrees). The indicated margins for such applications are very conservative since they do not account for the significant load contribution of the supply lines and the relatively low height of the communications attachments.

As for the tangent lines, in the event that the existing margin is not sufficient for a pole at a line angle and a formal loading analysis is required, the updated results may be used to determine the new margin and the next occasion on which such an analysis is required, using the same guidelines.

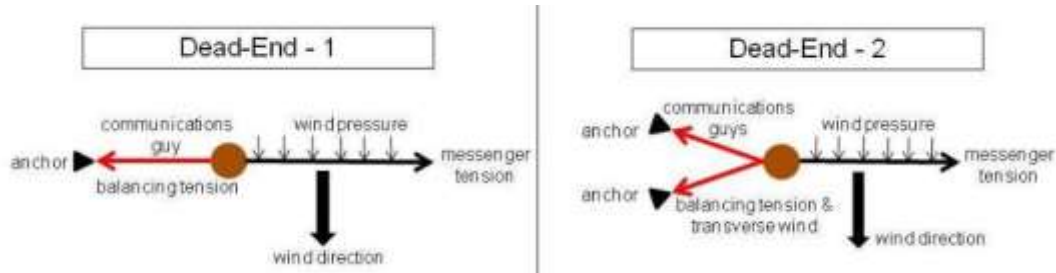
### **CASE #3 – Dead Ends**

At a dead-end (or false dead-end) pole, the supporting guy(s) may be configured to only balance the messenger tension (Dead-End - 1), or to also support the transverse wind load imposed on the pole (Dead-End - 2); see Figure 13-6. Similar to the case of the line angle, the margins in Table 13-7 for the Dead-End-1 configuration are considered applicable to the communications guy system, and those in Table 13-6 are applicable to the pole. However, for the double-guyed system (Dead-End - 2), only Table 13-7



is necessary, since the guys provide support for the transverse wind load in any direction.

**Figure 13-6 Load Analysis for Dead end Pole Scenario**



#### 13.10.4 Summary Over-Lash Guidelines

When adding a new attachment to a pole line, it is always an option to perform a full pole loading analysis (PLA) and may be necessary or required for documentation purposes, or for complicated configurations which may be otherwise difficult to analyze by other simpler methods. However, such a formal study is often not necessary, especially if the purpose is to determine if particular poles would remain compliant with the NESC with the added lines or facilities. Possible alternatives to a formal PLA include:

**A) Comparative or Reference Pole Comparison:** When considering a new attachment, compare the pole(s) in question to another, more-heavily loaded pole which is known to be compliant. This approach may be based on particular cases, or possibly on “standard” design scenarios (e.g., including pole Class, span length, number and size of attachments, and type of attachments, ...) that the utility has previously evaluated. This procedure would be applicable to tangent structures and those at line angles or dead-ends.

**B) Critical or Weakest Link Approach:** For a new attachment (or set of attachments) to be placed along a pole line, all with similar set of attachments, it is only necessary to analyze the most severely loaded pole – i.e., the longest span and/or weakest pole (i.e., Class).

**C) Pole with Previous PLA Available :** For a new strand and cable attachment to a tangent line, the incremental transverse wind load and corresponding effect on the pole may be estimated by a relatively simple analysis process, and compared to the available remaining capacity based on the previous PLA. For guyed poles, the procedure may require an estimate of the peak (storm) tension, which may be obtained using industry-available software (e.g., SpanMaster® by Commscope®, provided as a courtesy to the industry). Although these incremental loads are often relatively low, and

well within the remaining capacity, it is recognized that the process of adding an additional messenger strand is a convenient opportunity to perform a PLA for a representative pole.

Similarly, the incremental load owing to the addition of a pole-top antenna for a tangent line, and possible auxiliary cables and equipment, may be readily estimated and compared to the remaining capacity, but such an addition may also be a convenient opportunity to perform a PLA.

**D) Overlashed Cables:** Overlashing a cable on an existing strand is a special case of an attachment. When a licensee or attaching company is submitting an application for such an attachment, it is recommended that – in addition to the diameter and weight for any added cable(s), and assurance that the tension limit of 60% RBS is not exceeded – the approximate size (diameter) of the resulting bundle and an estimate of the actual subsequent tension at installation and under storm loading be provided. This information may be obtained using an industry available software engineering tools, and will possibly help avoid the overly conservative calculations resulting from a PLA, if or when that analysis is performed. If the overlashing event includes the addition of strand-mounted equipment, located close to the pole, the additional equipment may be considered as an additional overlashed cable for the purposes of applying the proposed guidelines.

The FCC has ruled that a PLA is generally not necessary for an overlashed cable(s). However, the guidelines discussed above provide some specific recommendations to help ensure poles are not overloaded or unnecessary replacement occurs to place larger poles .

### 13.11 Non-Wood Pole Factors

The preceding discussions in this chapter focused on wood poles (GR-60). The principal pole material alternatives are concrete, steel and fiberglass with various structural designs offered in each material class (GR-3159), including the following:

- Concrete
  - Solid Concrete versus Pre-Stressed Concrete
  - Spun Cast versus Statically Cast.
- Steel – Tubular Steel Designs
- Hybrid Poles – Concrete Base Supporting a Steel or Fiberglass Pole Top
- Fiber-Reinforced Composite (FRC) or Fiber-Reinforced Polymer (FRP)
  - Filament Wound

- Pultruded or Extruded
- Centrifugally Cast.

The loads imposed on these poles depend upon the storm loadings and other considerations described above. From a conservative, reliable design approach, the substitution of a wood pole with a fiberglass, steel or concrete pole should not reduce the structural robustness of the designed pole line.

Following this philosophy, the strength factors used for the different pole materials are typically 1.0 for most of the non-wood pole materials. Current NESC guidance for the strength factors for non-wood structures is given in [Table 13-8](#)

**Table 13-8 Strength Factors for Structures - Derived from NESC Table 261-1**

| Condition<br>NESC Rule                                                                    | Structure                                   | Grade B | Grade C |
|-------------------------------------------------------------------------------------------|---------------------------------------------|---------|---------|
| Basic Ice and<br>Wind<br>Rule 250B                                                        | Wood                                        | 0.65    | 0.85    |
|                                                                                           | Reinforced Concrete                         | 0.65    | 0.85    |
|                                                                                           | Pre-Stressed Concrete                       | 1.0     | 1.0     |
|                                                                                           | Metal (steel)                               | 1.0     | 1.0     |
|                                                                                           | Fiber-Reinforced Polymer<br>Composite (FRC) | 1.0     | 1.0     |
| Extreme Wind<br><br>Rule 250C<br><br>and<br><br>Extreme Ice<br>with Wind<br><br>Rule 250D | Wood                                        | 0.75    | 0.75    |
|                                                                                           | Reinforced Concrete                         | 0.75    | 0.75    |
|                                                                                           | Pre-Stressed Concrete                       | 1.0     | 1.0     |
|                                                                                           | Metal (steel)                               | 1.0     | 1.0     |
|                                                                                           | Fiber-Reinforced Polymer<br>Composite (FRC) | 1.0     | 1.0     |

### 13.12 Normative and Informative References Related to Pole Hardware

1. ANSI 05.1 *American National Standard for Wood Poles – Specifications and Dimensions.*
2. ASCE-7 (ASCE/SEI) *Minimum Design Loads For Buildings and Other Structures.*
3. ASCE-48 (ASCE/SEI) *Design of Steel Transmission Pole Structures.*
4. ASCE-74, *Guidelines for Electrical Transmission Line Structural Loading.*
5. ASCE-111, *Structural Reliability-Based Design of Utility Poles.*
6. IEEE P751/D2, *IEEE Design Guide for Wood Transmission Structures*, IEEE Power Engineering Society.
7. GR-60-CORE, *Generic Requirements for Wood Utility Poles.*
8. GR-3159-CORE, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles.*
9. *“Overhead Distribution Lines – Design and Applications”* by Lawrence M. Slavin – IEEE Press – Wiley 2021.
10. AT&T Practices - *Outside Plant Engineering Handbook* (900-200-318, Lucent Technologies, October 1996.

## 14 Supply Equipment In or Near the Communications Space

### 14.1 General

This chapter covers locations for power supply equipment (meters and supply boxes) and amplifiers used in licensee systems to power communications systems and covers the grounding arrangements for the power supply units. This particular powering equipment meets the definition of “communications equipment” and is in harmony with the definition of supply equipment and communications lines in the NESC:

**communications equipment.** *Equipment that produces, modifies, regulates, or controls communications signals. This equipment may also produce, modify, or safeguard a supply of electric energy for the exclusive use of communications devices as long as the equipment and communications devices being served are owned and operated by the same party.*

.....

**communication lines.** *The conductors and their supporting or containing structures, equipment, and apparatus that are used for public or private signal or communications service.*

*a. located in the communication space. Communication lines located in the communication space and which operate at potentials not exceeding 400 V to ground or 750 V between any two points of the circuit, and the transmitted power of which does not exceed 150 W. When operating at not more than 90 V ac or 150 V dc, no limit is placed on the transmitted power of the system.*

*Lines used for signaling purposes, but not included above, are supply lines of the same voltage and are to be so installed.*

*Note: Public and private telephone, telegraph, railroad-signal, data, clock, fire, police-alarm, cable-television, and other systems conforming with the above are examples of communication lines.*

*b. located in the supply space. Communication lines located in the supply space and meeting Rule 224A. See: supply space.*

Electric supply equipment does not include equipment whose sole purpose is to provide power to support locally mounted communications systems. Such circuits are covered under Rules 224 and 344 of the NESC. For example, such power supplies support CATV amplifiers, communications repeaters, span powering circuits and FMPS (Fault Managed Powering System) are considered communications lines/ equipment for the purpose of the NESC.

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**Note:** See Sections 2.2.1 and 10.8 for discussions on FMPS circuits as well as Chapter 15 for further discussion on the placement of power supply boxes and other pole-mounted equipment associated with wireless installations.

Additional discussion has been added covering newer types of supply equipment that may be located in or near (below) the communications lines and equipment and that help create further congested poles, as described in [Section 3.3.1](#). Supply equipment can possibly be found not only in supply space, but also in communications space and common space of the pole. These power supply units may be (1) serving communications circuits, equipment, and antennas, and (2) be used as distributed power sources for generating local power that is fed back into the main power grid.

The figures and schematics in this chapter cover general situations only. It will be necessary for the licensee to obtain communications company approval for the method of installation of pole-mounted equipment. Particular attention must be given to concerns of adequate climbing space ([Section 3.9](#)) and working space.

Poles having power supplies or amplifiers with communications company distribution terminals and service drops may require the placement of pole steps to provide safe climbing conditions. This work shall be part of the agreement between the communications company and the licensee.

**Note:** Power supply units and amplifiers used in authorized licensee arrangements will not be installed in manholes. If an exception is required for in-line amplifiers, the communications company must approve. Conformance with the definition of communications lines (see below) and communications equipment (see above) contained in the NESC must be satisfied. This also applies to [Chapter 16, “General Precautions and Work Rules for Manholes.”](#)

Additional methods of installing and mounting power supply units not covered in this chapter may be approved by the communications company, or by the communications and electric utility companies when the facility is jointly owned. The licensee must obtain approval for these installations from the company or companies, as required.

## 14.2 Metered, Unmetered and Span Powering

There are several factors to be considered when determining whether unmetered or metered service is appropriate and if metered, where best to site the meter and ancillary electrical equipment. Because of the variable nature of the small wireless cell consumption, electrical utilities may favor or require a metered service that can account for the varying consumption, particularly if the energy consumption exceeds a certain level.

Most electrical services are provided under tariffs filed with the State Public Utilities Commission or similar entities that require meters to measure actual energy consumption. The exceptions have historically been third party power usage in the public right of way by such as used for

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roadway/street lighting customers and including communications CATV providers for powering amplifier installations.

With an expanding multitude of new powered communications and smart grid devices on poles, such as small wireless cell installations, traffic monitors and security cameras, the existing unmetered tariffs may or may not be appropriate or applicable in specific areas. The unmetered tariff rates were created for lighting applications that use a well-defined maximum power consumption rates for equipment that only operates on a fixed or predictable cyclical demand.

The power consumption of modern wireless facilities varies as a function of load on the communications network over day/night and other seasonal communications traffic demands. In addition, the rapidly changing wireless technology has modified the energy efficiency of equipment, and the maximum power demands for each individual component vary over time.

### 14.2.1 Background - Powering for Communications Circuits

The traditional powering architectures for communications began with the 48V-dc Plain Old Telephone Service (POTS) with the power distributed from the Central Office (CO) out to the individual customer premises equipment. As demands for more and more communications services developed the power generation and distribution facilities have moved further out into the local loop and even to the customer premises under the Fiber-to-the-home (FTTH) architectures.

Communications service providers have used span powering circuits within twisted pair cables to power communications equipment. All the latest wireless facilities will require power for their operation and various configurations are being designed and trialed; including remote power circuits (also called span powering) incorporated inside twisted pair and hybrid (fiber/twisted pair) communications cables.

For the OSP (Outside Plant) sites covered under the NESC which serve traditional telecom service providers as well as CATV, Wireless/Cellular, and ISP providers, the typical range of powering circuits consist of the following:

- A.) Primary power feed of 120/240 volts AC or 120/208 volts AC from the AC utility power grid serving an OSP facility (e.g., telecom hut or cabinet) under a metered service.
- B.) The common line-powering or span-powering voltages for telecommunications equipment include the following:
  - 60 and 90 volts AC for CATV architectures,
  - -130 or  $\pm 130$  volts DC for legacy T1 architectures or some Fiber-To-The-Curb (FTTC), FTTN (Fiber-to-the-node), and in smaller DLC or DSLAM architectures,
  - -190 volts DC for HDSL architectures, and

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- $\pm 190$  volts DC for longer range FTTC and other communication services architectures.

These powering architectures all have various safety rules and agreed powering limitations, which are usually covered under the GR-1089 standard. For example, except for some of the 60 volts and 90 volts AC architectures, the circuits usually all meet the 100 VA limit as outlined in GR-1089.

- C.) Rectification components that includes an AC-DC conversion process/devices and various filtering steps to help provide power to the telecommunications equipment.
- D.) Backup power capacity consisting of batteries to provide energy reserves to continue essential telecommunications services during an AC utility power failure as well as the connection capability for portable engines. In contrast to older network architectures, it is assumed that current and future OSP facilities will require higher and higher energy demands and, therefore, will require increased energy storage densities for their backup powering systems.
- E.) Reverse Powering – In addition, as the passive FTTx networks expand deeper into the local loop, the powering architectures will include telecommunications equipment that obtain their power from the AC supply at the customer premises.

The traditional communications powering circuits are defined by such standards as GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment* and ATIS-0600030, *Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops*. The nominal voltage ranges are shown below in Table 14-1.

**Table 14-1 Line-Powering Voltages Ranges**

| Nominal Line-Powering Source End | Operational Voltage Range for End-Use Equipment | Wide Range Maximum Operating Voltage for End-Use Equipment | Wide Range Minimum Operating Voltage for End-Use Equipment |
|----------------------------------|-------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| -48 Vdc                          | -30 to -56                                      | -60                                                        | -27                                                        |
| -130 Vdc                         | -70 to -140                                     | -150                                                       | -65                                                        |
| $\pm 130$ Vdc                    | $\pm 70$ to $\pm 130$                           | $\pm 150$                                                  | $\pm 65$                                                   |
| -190 Vdc                         | -100 to -195                                    | -200                                                       | -95                                                        |
| $\pm 190$ Vdc                    | $\pm 100$ to $\pm 195$                          | $\pm 200$                                                  | $\pm 95$                                                   |

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The growing demands for 5G (and 6G in the future) wireless services requires more antennas and associated equipment with concomitant demands for additional power to serve these facilities. Using individual meters for small Wi-Fi cells and strand-mounted wireless equipment is very inefficient and impractical since such added meters will create more congestion on the pole and management of billing from each meter will complicate power management.

Instead of metered service for the power company, there are several powering architectures that use existing or new copper pairs of communications cables to provide power exclusively for the wireline and wireless communications equipment in accordance with NESC Rules 224 and 344. These are known by various terms including “span powering” or remote-powering where the power generation occurs at a traditional Central Office, switching office or network node (telecom huts and cabinets) locations that may be located adjacent to the pole or many hundreds of meters (feet) away.

The design and application of span powering architectures are controlled and mediated by standards such as ATIS-0600030 “*Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops*”, ANSI/ATIS-0600337, *Requirements for Maximum Voltage, Current, and Power Levels in Network-Powered*, and GR-1089-CORE, *Telcordia Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*.

Several innovative powering circuits and architectures are being proposed and deployed including the use of a pulsed power solution known as FMPS (Fault Managed Power Systems) or Class 4 power circuits. This FMPS has been developed with details found in a 2021 Technical Report ATIS-06000040 entitled “*Fault Managed Power Distribution Technologies – Human Contact Fault Analysis*”. FMPS circuits is a powering system for communications equipment that monitors for electrical faults and controls the current delivered to limit fault energy. FMPS consist of a power transmitter and a power receiver connected by a cabling system. These systems are characterized by monitoring the circuit for faults and controlling the power transmitted to ensure the energy and power delivered into any fault is limited with respect to electric shock between transmitter and receiver.

In the case of a fault, the FMPS will de-energize the circuit in less than 10 milliseconds similar to a GFCI circuit inside a house. The monitoring and control systems differentiate fault-managed power from electric light and supply power circuits with different requirements regarding minimum wire sizes, overcurrent and surge protection, insulation requirements, and wiring methods. ATIS Technical Report 600040 - *Fault Managed Power Distribution Technologies - Human Contact Fault Analysis* provides description of FMPS and testing protocols. FMPS circuits are also referred to as Class 4 circuits, along with other industry specifications and standards:

- ATIS Technical Report #0600040 Fault Managed Power (FMP) Distribution Technologies – Human Contact Fault Analysis
- ATIS subtending document – ATIS-0600040.01 Fault Managed Power Systems – Interlock Equipment Barriers for Limiting Access to Energized Conductors and Terminals via Contact Preclusion
- Articles 722 and 726 of 2023 NFPA 70 (NEC) for Fault Managed Power Circuits and Systems designated as Class 4 (CL4) systems.
- UL (Underwriters Laboratory) 1400-1 Outline of Investigation for Fault-Managed Power Systems - Part 1: General Requirements which contains Listing requirements and testing protocols for FMPS equipment
- UL 1400-2 Outline of Investigation for Fault-Managed Power Systems - Part 2: Requirements for CL4 Cables for use with Class 4 (FMPS)

All these powering circuits and cables need to be configured on already congested joint-use structures while meeting NESC and industry best practices. The configurations shown in this chapter endeavor to combine various generic principles of clearance and separation to enable work to be performed safely and efficiently on joint-use poles and structures. These principles include:

- Adequate ground clearance (NESC Rule 232)
- Protective guards and conduits for interconnection cables (NESC Rule 239)
- Sufficient separation between communications space and supply space (NESC Rule 238), as follows:
  - 40 inches is the CWSZ (Communications Worker Safety Zone) between communications lines and power supply conductors and metering equipment
  - Sufficient working space above and below the communications lines
  - Sufficient climbing space or access options for communications workers.

As discussed in [Section 3.3.1](#), the presence of a wider variety of supply type equipment in the traditional communications space is presenting issues and concerns particularly related to the following:

1. The type of equipment permitted in that communications space in terms of its:
  - Connections to a grounded system or ground rod
  - Electrical isolation to help protect personnel and devices from possible damage from grid voltages and fault currents.
2. Necessary grounding and bonding configuration for such equipment.

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3. Physical protection of interconnection cables – particularly those connecting the equipment to the supply grid conductors.
4. Maintenance of adequate working and climbing space above, below, and around the equipment.

Section 14.3 and Section 14.4 present the configurations for traditional power supply units serving communications lines (coaxial cable systems). Section 14.5 and Section 14.6 expand the discussion to include guidelines for the powered antennas, distributed power generation devices and other “supply equipment” being proposed for, or presently located in, traditional communications space.

***The final location of any power supply source must be approved by the communications (telephone) company as the pole owner or joint user of the pole.***

### 14.3 Power Supplies

Power supplies can be found in the supply space, communications space and common space of the pole, as well as attached to communications strand. These power units may (1) be serving communications circuits, equipment, and antennas,

(2) provide power to street lighting and traffic lights, and (3) be used as a system component of distributed power sources for generating local power that is fed back into the main power grid.

Regular power meter housings are designed to attach to houses and commercial/industrial buildings, so the form factor and access requirements are not designed to readily fit to vertical infrastructure such as roadway/street lighting structures and utility poles and may require additional mounting hardware and methods that deviate from those associated with installations on buildings.

Some utilities may resist mounting meters on utility poles, because of several reasons that can include safety concerns (a communication worker or lineman working on a pole with a meter may damage the glass or plastic dome of the meter and create a hazard or the meter and associated cabling may obstruct required climbing space), potential for vandalism/theft of the metering equipment, or lack of space for a meter installation owing to clearance issues such as multiple vertical runs/risers on a utility pole. In such cases, the AC/DC supply equipment are often located in ground-based based closures or cabinets, or else span powering/FMPS power architectures are used to avoid having pole-mounted meters or closures.

An alternative would also be to create meters or power supplies with smaller form factor to obtain the necessary powering service to support a small cell installation in a safe and economical manner, while meeting all applicable codes, rules, regulations and laws.

### 14.3.1 Power Supply Grounding

***Licensee power supply cabinets made of electrically-conductive material must be installed according to the NESC and local electrical code requirements, and must be grounded.***

**Note:** In the current NESC, the term “effectively grounded” is used. In this Blue Book, the term “grounded” is considered equivalent to the NESC term “effectively grounded.” See Chapters 10 and 25 for further discussions and guidance on grounding and bonding for communications systems.

The grounding arrangement as shown in the figures applies except if local requirements specify otherwise. In such circumstances, the local requirements shall be complied with. Where the power supply cabinet is located on the same pole as a power company vertical ground wire connected to a Multi-Grounded Neutral (MGN), the cabinet may be grounded to the vertical ground wire, eliminating the need for an additional ground rod. This may be done only with the consent of the power company.

Vertical ground wires of power systems other than MGN will not permit the elimination of an individual ground rod for grounding the cabinet. Where there are two ground rods, they must be connected to each other.

The neutral side of the power circuit must be continuous and not fused.

Alternating current power supply lines between power company facilities and licensee power supply cabinets must be inside an insulating conduit, as shown in [Figure 14-1](#) and [Figure 14-2](#).

Power supply units must not be installed on poles having cross-connecting terminals, pole-mounted closures, or other large pole-mounted communications company facilities. Likewise, they must not be mounted on junction poles, risers, or on poles in a way that may restrict access to or conflict with strand-mounted terminals and equipment.

As shown in the figures, locating and installing the power supply lines requires adequate space to bend the cables and permit the craftsperson to work on the terminal with the least interference and an acceptable margin of safety.

**Note:** In [Figure 14-1](#) and [Figure 14-2](#), a minimum ground clearance of 8 feet is shown, although larger clearances are preferred. For reference, the location of equipment mounted on poles is covered under Table 232-2 of the NESC Rule 232B3 that permits through footnote 5 of that table that “*mounting at lower level for accessibility as long as the grounded equipment does not unduly obstruct a walkway.*” NESC Rule 239D identifies 8 feet above ground as a minimum below which additional guarding and protection measures may need to be provided. The assumption is that the closures and equipment are not hanging over a road or will not obstruct pedestrian activity.

**Note:** NESC Rule 238 provides the basic guidance for the separation/clearances between supply equipment and communications lines of 40 inches for the CWSZ with some allowance to be reduced for well-defined, low-power equipment that is grounded.

Storage battery stand-by power supply units may be installed if safety aspects of climbing space, weight distribution, and clearances are not violated. There must be only one power supply installed on any one pole.

Section 14.3 and the plant configuration schematics shown in Figure 14-1, Figure 14- 2, and Figure 14-3 illustrate the clearance and grounding methods for power supply units used to serve traditional coaxial cable systems.

These configurations have been used safely and successfully for many years, and have been shown to provide adequate working and climbing space for communications workers to safely perform routine installation, maintenance, and repair work on the communications plant. For example, the 30-inch separation shown in Figure 14-1 and Figure 14-2 between the lowest communications line and the top of the power supply box provides sufficient working space for a technician installing or working on the lowest communications line.

Additionally:

1. The reverse side of the pole is clear of equipment and is therefore available for the technician to safely and efficiently climb the pole, or for the placement of steps in the pole above the required 8-foot ground clearance.
2. The power feed and meter for the power supply unit are located beneath the power supply closure (typically 12 to 18 inches in height), which places the power cable feed more than 40 inches below the lowest communications line.
3. The power cable feeding the communications circuit is guarded and protected inside a conduit.
4. The communications circuit being fed is power limited.

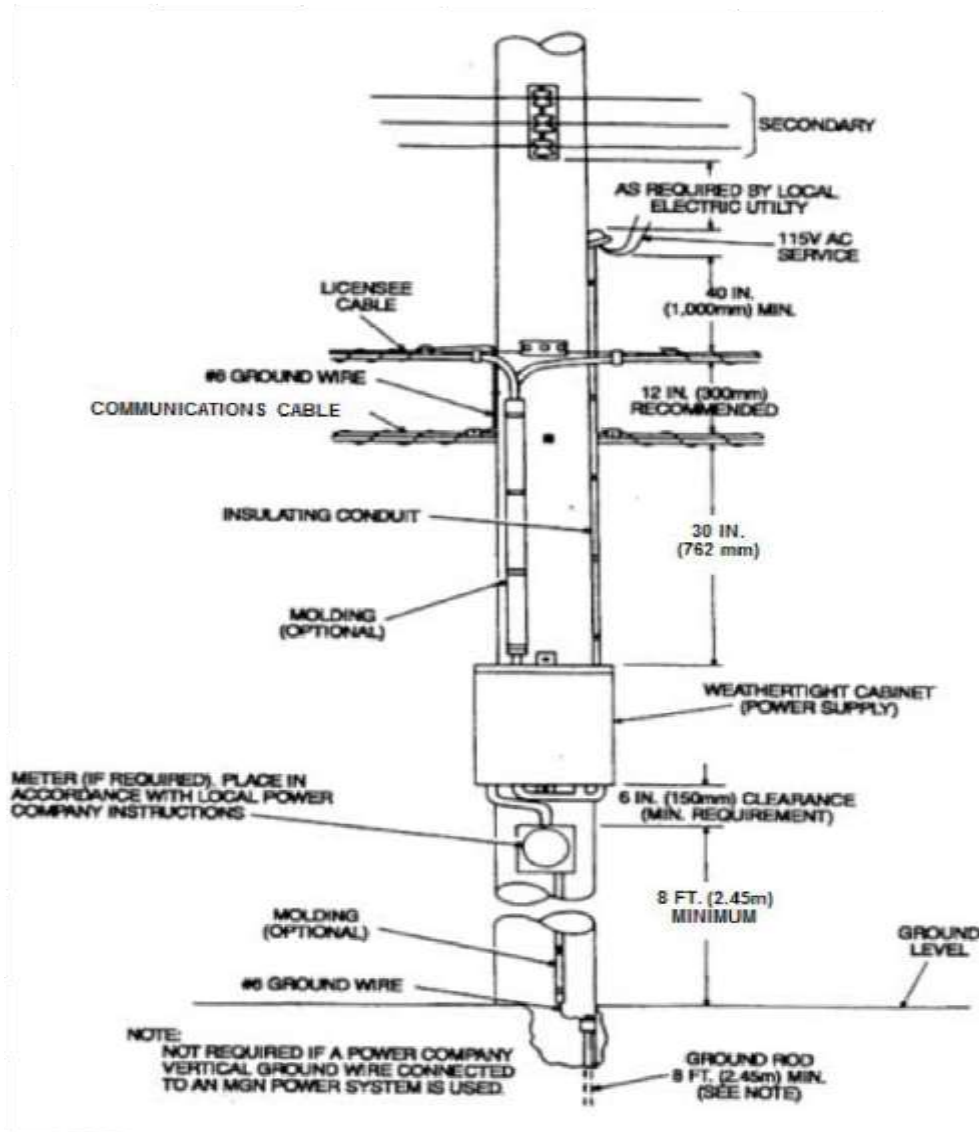
These clearances and equipment configurations help maintain worker safety and equipment reliability.

With FMPS schemes, the circuits may not need to be grounded or necessarily have shielded cables because of the inherent safety features of the software controls that limit exposure and rapidly automatically deenergize the circuit under fault conditions. However, the messenger strands and metallic closures that support the FMPS cables will still need to be bonded and grounded as per discussions in Chapter 10.

***As noted above, the final location of any power supply source must be approved by the communications company as the pole owner or joint user of the pole.***

Where the licensee cable is on the opposite side of the pole from the communications company cable, install the power supply on the side of the pole as shown in [Figure 14-1](#).

**Figure 14-1 Clearance and Grounding Methods for Power Supply Cabinet - Communications Cable and Licensee Cable on Opposite Sides of Pole**



If the licensee cable or terminal is installed on the same side of the pole as the communications (telephone) company cable and terminal, locate the power supply as shown in [Figure 14-2](#).

Locating the power supply on the opposite side of the pole from the terminal will cause the least inconvenience for the craftsman performing a work

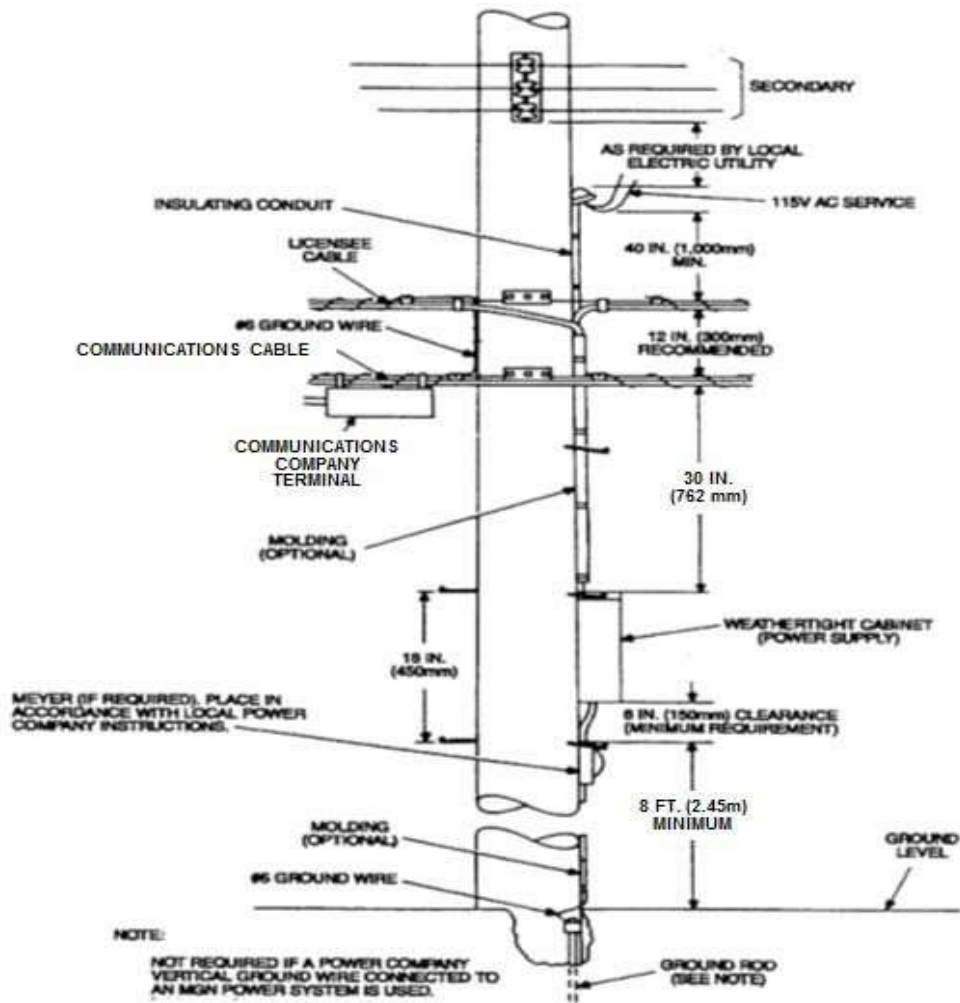
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operation at the terminal. If there is no terminal on the pole, the power supply may be installed on either side of the pole.

**Figure 14-2 Clearance and Grounding Methods for Power Supply Cabinet - Communications Cable and Licensee Cable on Same Side of Pole**

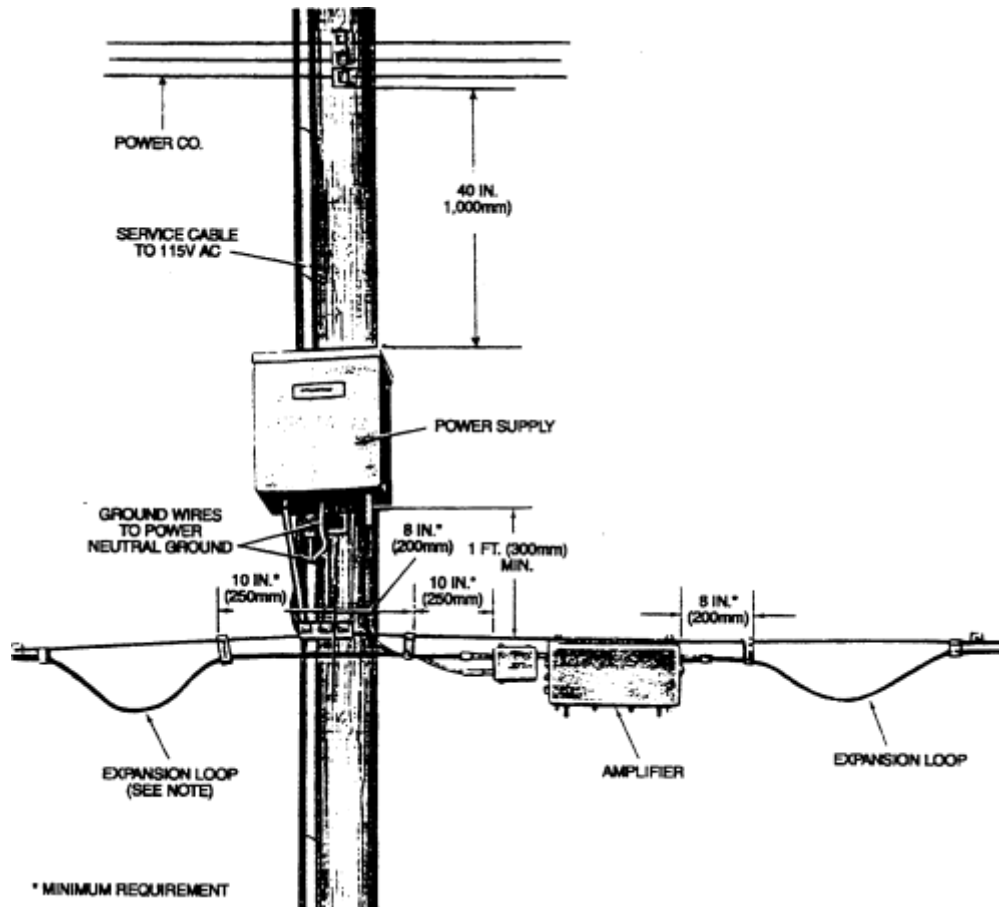


On a pole with adequate clearance, the power supply can be located as shown in [Figure 14-3](#). Adequate clearance in these terms means:

- Having sufficient space above the communications lines to place the power supply unit at least 12 to 18 inches above the topmost communications line,

- While still having space for the 40-inch clearance from the top of the power supply unit to the lowest supply conductor. This 40 inches constitutes the CWSZ between the supply space and communications space.

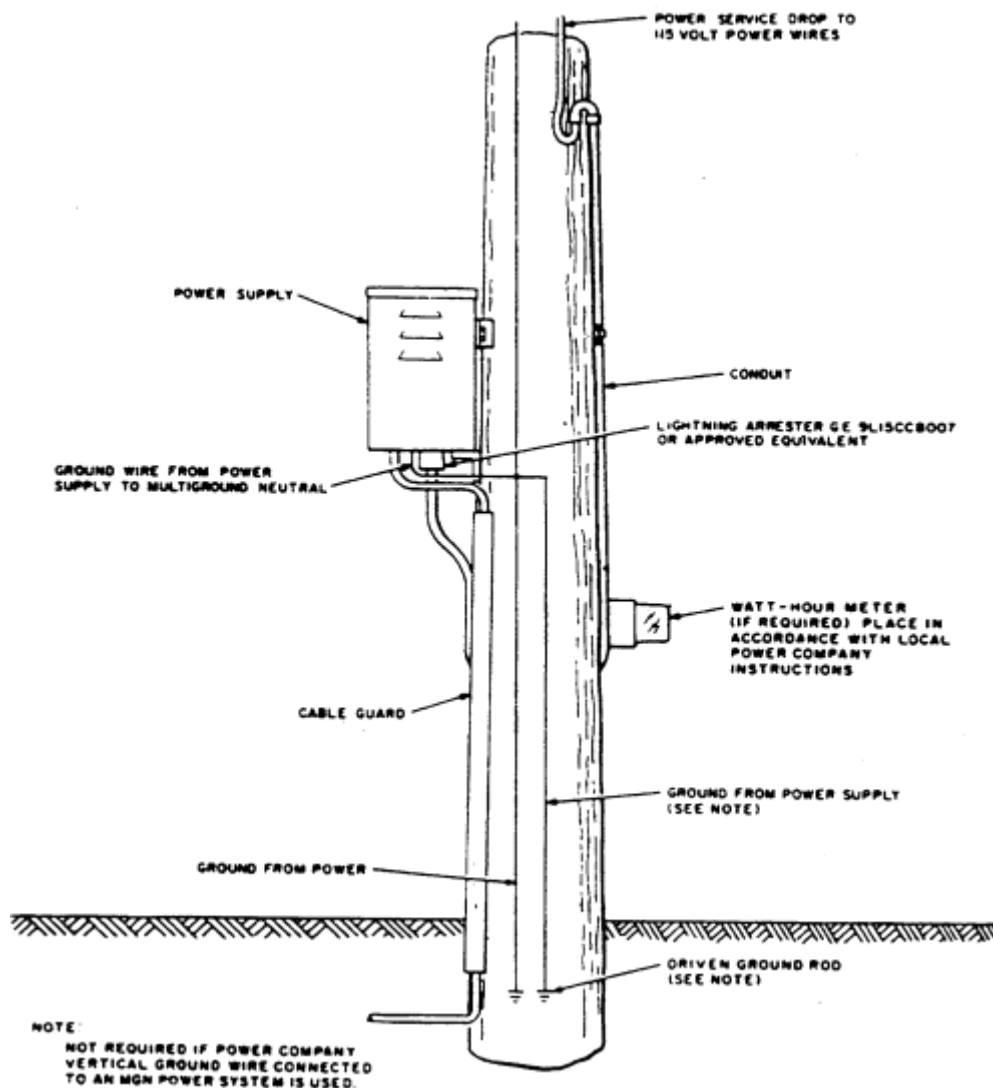
**Figure 14-3 Power Supply Location Where Sufficient Clearance Above Cable Is Available**



**Note:** The expansion loop must be placed to the right or left side of the pole with a minimum of 10 inches from the bolt to the first cable attachment.

Figure 14-4 shows a suggested location for a power supply that provides electrical current to a buried or underground cable.



**Figure 14-4 Power Supply Location Serving Buried or Underground Cable**

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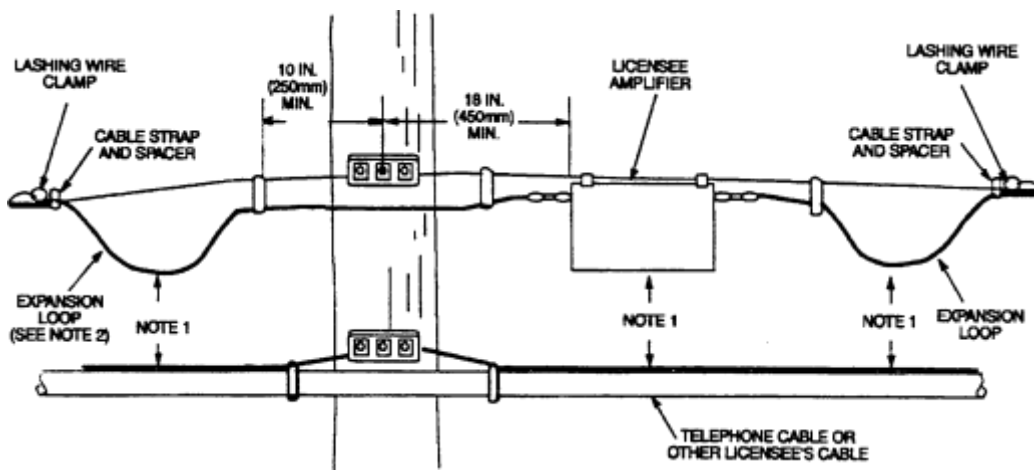
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## 14.4 Locations of Amplifiers Serving Coaxial Networks

A minimum vertical clearance of 6 inches is required between a licensee's cable expansion loop or strand-mounted amplifier and a suspension strand of another licensee of the communications (telephone) company. Where this vertical clearance cannot be maintained, the expansion loop slack must be arranged in a horizontal fashion, or the amplifier must be relocated to provide proper clearance, or the licensee's cable attachment raised on the pole.

Figure 14-5 shows the cable support and spacer arrangement for a strand-mounted amplifier when the expansion loop is made on the opposite side of the pole from the amplifier or on the same side of the pole, but **not** between the pole and the amplifier.

**Figure 14-5 Cable Support and Cable Arrangement – Expansion Loop on Opposite Side of Pole from Amplifier**

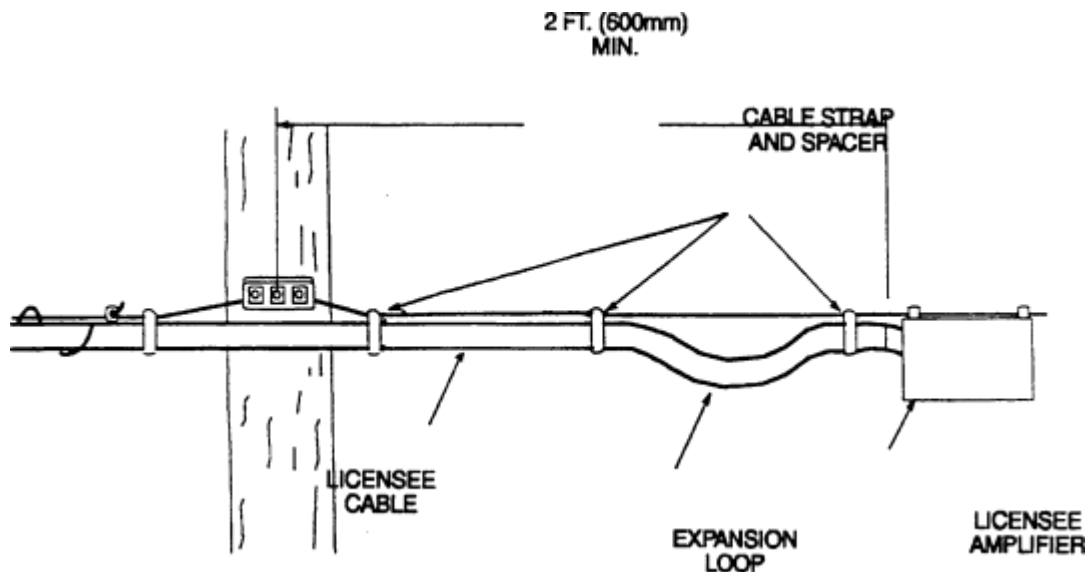


**Note:** [1] The minimum separation of 6 inches must be maintained.

[2] The expansion loop must be placed to the right or left side of the pole with a minimum of 10 inches from the bolt to the first cable attachment.

Figure 14-6 shows the cable support and spacer arrangement when the expansion loop is made on the same side of the pole as the amplifier between the pole and the amplifier.

**Figure 14-6 Cable Support and Spacer Arrangement – Expansion Loop on Same Side and Between Pole and Amplifier**



Modern hybrid-coaxial (HFC) networks have expanded the range and use of optical fiber cables and reduced the need (or eliminated) the use of amplifiers.

## 14.5 Communications Antenna and Associated Wireless Equipment

The reader should refer to [Chapter 15](#) and [Section 3.7](#) for a full discussion on the location and necessary clearances of antenna structures and their associated cables, closures, and hardware. As wireless networks expand (e.g., 5G networks), antennas of a wide range of RF powers and sizes are now being placed in a variety of positions on poles and crossarms - lower down in communications space. In urban environments, it may be difficult to find sufficient poles with adequate space above the supply space or in the communications space for antenna and associated boxes while maintaining:

- Sufficient clearance above the ground (NESC Rule 232)
- Maximum height to maximum cell coverage zone
- Adequate clearances from supply power facilities
- Adequate clearances from other communications equipment
- Adequate climbing and working space for other joint users
- Locations to minimize RF exposure effects to the public and workers on joint-use structures.

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## 14.6 Supply Facilities for Pole Top Facilities

For many wireless applications, the preference is to mount the wireless antenna on the top of the pole or on a pole top extension. In such circumstances, the powering supply and circuits would normally be located at the ground level in a cabinet, or pole-mounted in or below the communications space.

The cables delivering power and backhaul communications to the antenna at that pole top shall be contained in vertical risers (conduit) that pass up the pole, through the communications space, CWSZ, and the power space meeting requirements of NESC Rules 238 and 239 such as:

- Vertical cables/conduits shall be located so that they do not obstruct climbing spaces, or lateral working spaces between line conductors at different levels or interfere with the safe use of pole steps.
- All vertical runs of conductors and cables shall be guarded inside coverings, conduits or ducts within 8 ft (2.45 m) of the ground, or other areas readily accessible to the public.
- All vertical runs of communication conductors passing through supply space shall be installed as follows:
  - Vertical runs of metal-sheathed (shielded) communication cables shall be covered with suitable nonmetallic material, where they pass supply line conductors. This nonmetallic covering (duct/conduit) shall extend from a point 40 inches above the highest supply conductors, to a point 6 feet below the lowest supply conductors.

EXCEPTION - Where the cable terminates at an antenna in the supply space meeting Rule 238F, the nonmetallic covering need only extend to the antenna bracket.

- Vertical runs of communication conductors or cables shall have a clearance of one eighth of the pole circumference but not less than 2 inches from exposed through bolts and other exposed metal objects attached thereto that are associated with supply line equipment.

The powering circuits and the supporting communications cables that serve wireless antennas and associated equipment will often run vertically up the pole since the antennas may be located at the top of the pole or out on crossarms or support braces while the powering and backhaul equipment are located lower down on the pole or are ground based locations in cabinets. Apart from RF exposure warning labels needed for the operating antenna (see Chapters 14 and 15), it is also useful to distinguish the individual vertical riser conduits that may be present. Color coding of the conduits can be employed to discriminate between supply cable risers, communications risers from underground plant, optical fiber runs and wireless related cable runs.

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## 14.7 Supply Facilities in Locations Near Communications Space

As discussed in [Chapter 3 \(Section 3.11\)](#) a variety of new supply equipment is being planned and placed on joint-use poles around the country including:

- Smart-Grid devices for monitoring and controlling supply equipment
- Interconnection nodes of Broadband of Power Line (BPL) systems for interfacing to the communications network
- Solar power assemblies designed as distributed power sources for supplementing the AC power grid.

Since these devices have a direct connection to the AC grid and its power supply line conductors, one major concern is if the CWSZ between communications and supply space is compromised. If such equipment is placed in the vicinity of communications lines, then the equipment needs to have certain attributes covered under appropriate safety and performance specifications such as UL 1741, *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*; or IEEE 1675, *Broadband Over Power Line Hardware*, which help ensure features such as:

- The conductive portions of equipment cases and supporting hardware shall be grounded for safety and sufficiently well isolated to avoid electrical influences that may lead to unacceptable noise on communications circuits.
- If the equipment is connected to a supply line, the voltage of the electrical circuits connecting the equipment to the supply line shall not be greater than 150 V.
- Circuits operating at communications line potentials shall be electrically isolated from any circuits connecting the equipment to a supply line. Equipment containing inverters shall utilize transformer isolation, and the inverter shall pass the Dielectric Voltage-Withstand Test of UL 1741.
- If the equipment provides energy to a supply circuit, it shall meet the requirements of IEEE 1547.

The use and installation of supply type equipment on joint-use poles (structures) should meet all the applicable parts of the NESC, including:

- Bonding and grounding rules of Rule 215C1 to help prevent induced and fault voltages/currents appearing on the communications circuits and thereby avoiding unwanted noise (see [Chapter 10](#)).
- Identification and marking rules of Rule 220E, to provide either detailed equipment information or contact information (e.g., ownership and contact phone number) located at the base of the pole or on the equipment itself to help identify the responsible party to contact with questions on the equipment.
- Ground clearance rules of Rule 232B3 and Table 232-2.

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- Providing sufficient climbing space in accordance with Rule 236D.
- Providing sufficient working space around communications lines and equipment in accordance with Rule 237A.
- Maintaining clearances from communications equipment as per the applicable sections of Rule 238 to help maintain the CWSZ around communications lines and equipment.
- Following the applicable work rules of Part 4 of the NESC, e.g., Rules 411E (Identification and Location), 420E (Ungrounded Metal Parts), and 422B (Checking Structures Before Climbing).

For such supply type equipment, the baseline options for construction engineering purposes would be as follows:

1. Keep supply equipment in supply space as far as reasonably possible and have any interconnection cables coming to or passing through the communications space guarded and protected in conduit.
2. If necessary to be placed below the communications lines, the supply type equipment should be
  - Placed at least 30 inches below the lowest communications line – For supply type equipment meeting the criteria noted above, one can use a similar clearance distance as that used between communications lines and power supply boxes as shown in [Figure 14-1](#) and [Figure 14-2](#).
3. If necessary to be placed above communications lines, but below the power supply space, then the equipment should be
  - Placed at least 12 inches above the topmost communications line, i.e., similar to the clearance distance used between communications lines and the power supply box as shown in [Figure 14-3](#).
  - Placed at least 40 inches below the lowest supply line conductor to help maintain an adequate worker safety zone.

## 14.8 References For Power Supplies for Communications Equipment

1. IEEE C2 National Electric Safety Code (2023) - Rules 224, 235, 238, and 344 in particular.
2. GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*
3. ATIS-0600030 - *Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops*.
4. ATIS-0600030 “*Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops*”
5. ANSI/ATIS-0600337, *Requirements for Maximum Voltage, Current, and Power Levels in Network-Powered*
6. ATIS Technical Report #0600040 *Fault Managed Power (FMP) Distribution Technologies – Human Contact Fault Analysis*
7. ATIS subtending document – ATIS-0600040.01 *Fault Managed Power Systems – Interlock Equipment Barriers for Limiting Access to Energized Conductors and Terminals via Contact Preclusion*
8. Articles 722 and 726 of 2023 NFPA 70 (NEC) for *Fault Managed Power Circuits and Systems* designated as Class 4 (CL4) systems.
9. UL (Underwriters Laboratory) 1400-1 *Outline of Investigation for Fault-Managed Power Systems - Part 1: General Requirements* which contains Listing requirements and testing protocols for FMPS equipment
10. UL 1400-2 *Outline of Investigation for Fault-Managed Power Systems - Part 2: Requirements for CL4 Cables* for use with Class 4 (FMPS)
11. UL 1741, *Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources*
12. IEEE 1675, *Broadband Over PowerLine Hardware*
13. IEEE 1547, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*

## 15 Wireless Facilities

This chapter provides guidance on design/engineering concerns, safety issues and work precautions associated with the various installations and applications of wireless network elements on utility poles and similar structures. There are several areas of specific note for these wireless installations over and above the general issues discussed in other chapters of the *Blue Book* (Chapters 3-14), including:

- **RF exposure levels and concerns** – These are addressed through effective implementation of a Radio Frequency Safety Program (RFSP), which includes posted warnings and pole markings ([Section 15.2](#)).
- **Pole markings and posted warnings** – The applicable and appropriate signage on, or in the vicinity of, the wireless facilities ([Section 15.3](#)).
- **Preferred locations for antennas and equipment on joint-use structures** – The choice of the relative position of antenna and equipment on the pole with

respect to power, wireline and other facilities is defined by meeting the NESC minimum clearances and separations in combination with minimizing RF exposure levels for workers and Electromagnetic Interference (EMI)/ Electromagnetic Compatibility (EMC) interference with adjacent equipment (see [Section 15.4](#) and [Section 15.5](#)).

### 15.1 General Overview

With the rapid expansion of interactive wireless devices available today and the continued growth envisioned in the future, utility poles, light poles and aerial strand are seen as preferred and cost-effective locations on which to deploy many new antennas and devices to provide the desired omnipresent network of the future. As call volumes and bandwidth requirements increase within a given wireless network cell, demand for frequency reuse has also been on the increase, with these wireless cells sometimes reaching their maximum processing capacity. Therefore, to fill existing coverage gaps and increase reliability of wireless coverage, many carriers are dividing larger sites into smaller ones (cells). Additionally, carriers are locating many smaller facilities lower down on the pole as an alternative to a more powerful pole, tower or rooftop device in a network evolution called densification.

As wireless and cellular services expand greatly, the infrastructure to support these services will include many new network components in the outside plant, including:

- **Antennas and associated equipment** located on:
  - **Utility poles** owned solely or jointly by communications or power utilities.

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The antennas may be located at the top of poles, in or above the supply space, on pole top extensions, or on cross arms extending horizontally out from the pole surface.

- **Light Poles** – Attached to existing community light poles or other non-utility poles.
- **Aerial Span** – Attached to or hanging off the utility strand between poles.
- **Buildings** – Antennas may be mounted on outside walls, on roof tops, in belfries and clock-towers.
- **Other Structures** – Non-pole or building attachments, including billboards, elevated signs and other elevated structures.
- **Internal Building Installation** (DAS systems) – Ceiling mounted or within drop ceiling spaces to provide wireless service in public and office areas. Current trends place many smaller (size and power) antennas called Microcells, Femtocells or Dots to enable the desired ubiquitous coverage.

**Note:** “DAS” = Distributed Antenna Systems or microcell systems made up of an array of antennas with coverage to a well-defined area inside a single building or around a campus/stadium zone. The DAS antennas are usually of low power and therefore distributed in higher density around the coverage space to attain the desired transmission performance.

- **Power supplies** to provide power for antenna RF emissions and associated electronics or opto-electronics for backhaul communications to local switching centers (MSCs or COs). This may include AC power feed from the utility grid as well as DC power feeds from local battery or rectifier equipment. These power supplies may be mounted on the same structure (pole) or located at ground level with cables running vertically to the wireless antenna/equipment.

**Note:** “MSC” = Mobile Switching Center and CO = Central Office  
 – The network architectures for wireless systems vary widely, and the MSCs may be co-located inside a CO or positioned in small huts or cabinets closer to the antennas with high-speed fiber links to the Public Switched Telephone Network (PSTN). The backhaul connections (usually fiber cable) to nearby switching facility are usually less than 15 miles defined by the optical loss budget (e.g., 10 dB) for the system.

- **Equipment closures** that may either be mounted on the pole or be located at ground level. The equipment provides connections to/from the antenna and associated equipment mounted higher up on the pole for powering and backhaul purposes.

The concerns with working space, climbing space, grounding/bonding, access to adjacent facilities and safety clearances are similar to those already discussed in other chapters of this *Blue Book*. This chapter covers these general access and working space considerations from a perspective of the

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necessary precautions and work rules that personnel working on, near, or around pole-mounted facilities are to be familiar with.

Pole owners, joint-users of structures, and wireless operators will need to work together to manage the potential exposure to RF radiation for personnel working in the vicinity of the antennas. Effective strategies to address these concerns include:

- Pole owners stating preferred locations on the pole for wireless facilities
- Operators of wireless transceivers have proper placement and current content for RF warning tags/labels on poles
- Effective communications channels among all pole users and owners
- Training of workers – In addition to general aerial plant safety training (which typically would include such topics as fall protection, electrical safety, etc.), the training should include appropriate RF training to enable the worker to recognize RF hazards, and the appropriate actions to take to reduce risk.

As part of the make-ready process and placement plans for wireless facilities, the RF exposure levels around the antenna must be considered. Decisions about which poles to choose for antennas, and where on a pole to attach an antenna, must take into consideration not only the restrictions to access introduced by the equipment, but also the service coverage benefits and the potential for exposure to RF energy for personnel approaching the antenna. The antenna's position on a pole is also to be considered in order to minimize the inclusion of other equipment within the radio frequency exposure boundaries where practical.

When considering the selection of possible antenna locations, the prevention of exposure to hazardous RF levels is not the only consideration. The effects of EMI on nearby equipment must also be evaluated. During make-ready surveys, this would include observing (and possibly avoiding) service points such as splice points and closures, nearby light poles (luminaries), power supply transformers, and other locations that are likely to have a high probability of being accessed by workers (communications, power utility, or other joint users of the structures).

Other precautions and requirements are more typically stipulated in the License Agreement between the pole owner (most often a communications company or power company) and the wireless facility operator. These may include details of the acceptable positions of the antenna on the pole, as well as stipulations of what types of precautionary communications are to be permitted, and allowable locations of the pole for such signage.

Figure 15-1 shows a generic schematic of wireless network architecture from GR-3171-CORE, *Generic Requirements for Network Elements Used in Wireless Networks Physical Layer Criteria*. Refer to GR-3171 and the companion GRs listed below for more details on the functional performance requirements for wireless equipment components:

- GR-3031-CORE, *Generic Requirements for Indoor Electronic*

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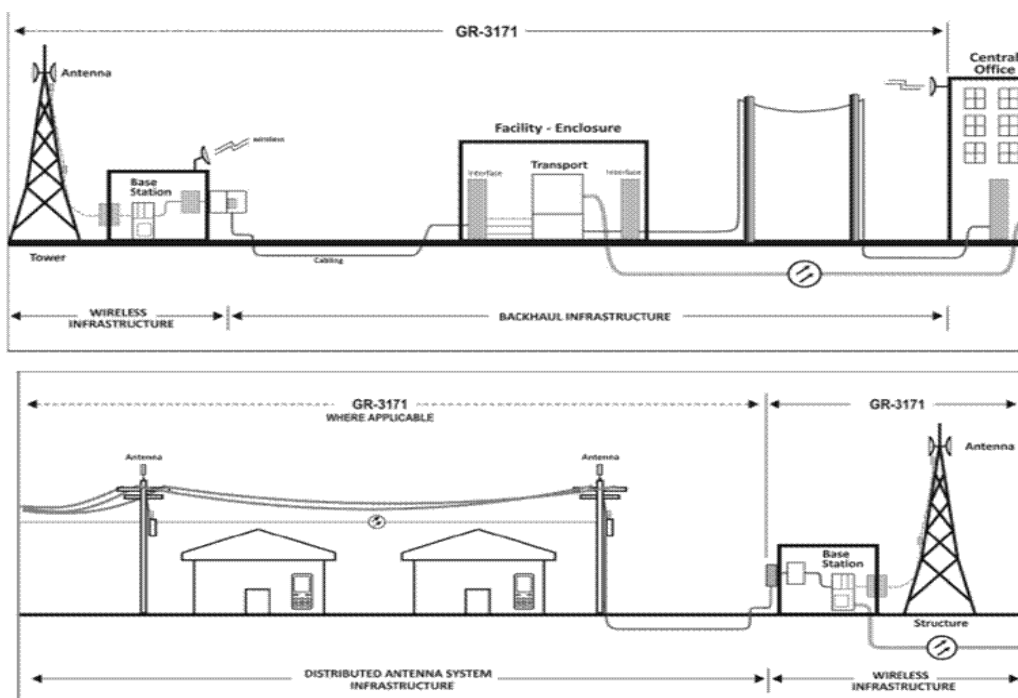
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### *Equipment Cabinets*

- GR-3032-CORE, *Interactions Between Generic Requirements Documents GR-3108, GR-487, and GR-950*
- GR-3033-CORE, *Generic Requirements for Indoor and Outdoor Battery Backup Cabinets*
- GR-3108-CORE, *Telcordia Generic Requirements for Network Equipment in the Outside Plant (OSP)*
- GR-3178-CORE, *Generic Requirements for Wireless Transceiver Facilities.*

**Figure 15-1 Wireless Infrastructure (from GR-3171)**



Refer to GR-3171 and the companion GRs listed below for more details on the functional performance requirements for protective closures:

- GR-43-CORE, *Generic Requirements for Telecommunications Huts*
- GR-487-CORE, *Telcordia Generic Requirements for Electronic Equipment Cabinets*
- GR-771-CORE, *Generic Requirements for Optical Fiber Splice Closures.*

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- GR-950-CORE, *Telcordia Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems*

See [Section 15.7](#) for a more complete list of relevant GRs.

GR-3171 contains useful guidance information and requirements for the wireless infrastructure components. Construction considerations for these network components should also include the necessary supporting structures (i.e., poles, towers, buildings), the attachment hardware securing the active components to these structures, and the powering schemes for these operating systems.

### 15.1.1 Network Components (or Elements)

There are four main component elements for wireless systems:

1. Wireless Transceiver Facilities (WiTFs) – Including the receiving antenna and transmitters of the RF energy and signals.
2. Powering Components – Power supplies and supply cables for the transmitting antenna as well as the active equipment used for communications and monitoring/control of the WiTFs.
3. Communications Components – Switching and transport type equipment used to accomplish backhaul communications between the remote site and the Mobile Switching Center (MSC) or Central Office (CO), as well as for the monitoring and control/alarm communications to the Network Operations Center (NOC).
4. Support Hardware – Poles, along with the mounting/attachment brackets, and with the protective closures for the various transmitting, power and communications components described above. This category will also include the attachment hardware used for securing components to building walls, rooftops and other structural frameworks.

As the popularity of smaller components and cells expands, the physical size and weight of the WiTF elements may decrease and, therefore, may require less robust brackets and a larger variety of configurations. The smaller antennas and their associated powering/control facilities are expected to be located in many usual and unusual places on poles, crossarms, strands, brackets and other structures.

The high demand for more 5G and 6G wireless installations is based on the promise of the multiple interactive services such as real-time vehicular communication to the internet and other vehicles to support autonomous driving car development, immersive Virtual Reality gaming, remote surgical operations (telesurgery) and simultaneous translating.

### 15.1.2 Regulatory Perspective

The Federal Communications Commission (FCC) is charged with regulating interstate and international communications by radio, television, wire, satellite and cable. The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions. The Commission staff is organized by function.

There are seven operating Bureaus in the FCC. The Wireless Telecommunications Bureau (WTB) handles all FCC domestic wireless telecommunications programs and policies, including licensing, enforcement, and regulatory functions. Wireless communications services include cellular telephone, paging, personal communications services, and other commercial and private radio services.

The FCC-WTB has reiterated the obligation of pole owners to provide wireless telecommunications providers with access to utility poles at reasonable rates pursuant to Section 224 of the Communications Act, 47 U.S.C. Within the implementation of Section 703(e) of the Telecommunications Act of 1996, the Commission determined that wireless telecommunications providers are entitled to the benefits and protections of Section 224 for the attachment to utility poles of antennas or antenna clusters and associated equipment.

The FCC does not have jurisdiction over pole attachments in states that certify to the Commission that they regulate pole attachments, unless the state fails to act on a pole attachment complaint for 180 days or complete action on the complaint for 360 days. As of 2022, the following 22 states and the District of Columbia have certified that they regulate pole attachments.

|               |               |                      |             |          |
|---------------|---------------|----------------------|-------------|----------|
| Alaska        | Arkansas      | California           | Connecticut | Delaware |
| Idaho         | Illinois      | Kentucky             | Louisiana   | Maine    |
| Massachusetts | Michigan      | New Hampshire        | New Jersey  | New York |
| Ohio          | Oregon        | Pennsylvania         | Utah        | Vermont  |
| Washington    | West Virginia | District of Columbia |             |          |

These circumstances result in many Local and State government agencies becoming involved in setting regulations and permitting requirements for the placement of Wireless Antennas, in addition to the licensing and joint-use agreements between communications and power utilities.

Section 332(c)(7) of the Communications Act preserves state and local authority over zoning and land use decisions for personal wireless service facilities but sets forth specific limitations on that authority. Specifically, a state or local government may not unreasonably discriminate among providers of functionally equivalent services, may not regulate in a manner that prohibits or has the effect of prohibiting the provision of personal wireless services, must act on applications within a reasonable period of time, and must make any denial of an application in writing supported by

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substantial evidence in a written record. The statute also preempts local decisions premised directly or indirectly on the environmental effects of Radio Frequency (RF) emissions, assuming that the provider is in compliance with the Commission's RF rules.

Furthermore, local licensing contractual obligations and joint-use agreements between utilities (power companies) can greatly influence which poles are, and what space on the pole is, available for the antenna and associated wireless equipment.

## 15.2 Radio Frequency (RF) Exposure

Wireless network growth can result in congestion on poles with antennas, support closures, and their interconnection cables competing for space with already installed communications and power facilities. The immediate focus of this *Blue Book* is the general precautions and safety-related work rules that must be observed when working around wireless equipment. In addition to fall and electrical hazards inherent to working aloft, a particular concern for wireless facilities is that they deliberately emit RF energy during their operation. RF or "Radio-Frequency" emissions are a form of electromagnetic non-ionizing radiation consisting of electric and magnetic energy waves moving through space. The RF hazard may not be limited to the pole on which the antenna is attached, but also on adjacent structures and vicinity.

The safety rules of NESC and OSHA require appropriate work rules (M&Ps) to be defined and followed for direct work on a pole with antenna transmitting elements, as well as for other employees working on adjacent or nearby facilities or equipment.

From NESC Rule 410A - General Requirements (2023 Edition of the NESC) 410A6 on Communications Antennas states:

*"... The employer shall provide training to all employees who work in the vicinity of antennas operating in the range of 3 kHz to 300 GHz to recognize and mitigate exposure to radio-frequency sources that exceed exposure levels set forth by the regulatory authority having jurisdiction.*

*Note: See OSHA 29 CFR 1910.97, Subpart G; OSHA 29 CFR 1910.268, Subpart R; FCC Bulletin No. 65; IEEE C95.1...."*

From NESC Rule 420Q on Communications Antennas (2023 Edition of the NESC):

*"....When working in the vicinity of communications antennas operating in the range of 3 kHz to 300 GHz, workers shall not be exposed to radiation levels that exceed those set forth by the regulatory authority having jurisdiction...."*

*As per standards such as OSHA 29 CFR 1910.97, Subpart G; OSHA 29 CFR 1910.268, Subpart R; FCC Bulletin No. 65; IEEE C95.1-2005*

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The allowable RF exposures are discussed in detail in relevant OSHA and FCC documents that primarily include the following:

- OSHA Standard 1910.268 covers communications workers under Subpart R for Special Industries – 29 CFR 1910.268, “*Telecommunications Industry*”.
- OSHA Standard 1910.097 covers general rules under Subpart G for Occupational Health and Environmental Control – 29 CFR 1910.097, “*Non-Ionizing Radiation*”.
- OSHA Standard 1910.269 covers power workers under Subpart R for Special Industries – 29 CFR 1910.269, “*Electric Power Generation, Transmission, and Distribution*”.
- FCC Bulletin 65 ([www.fcc.gov](http://www.fcc.gov)) - OET Bulletin No. 65, “*Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields*”.

### 15.2.1 FCC Exposure Guidelines

The FCC Office of Engineering & Technology Bulletin 65 (OET 65) discusses the evaluation of compliance with *FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields*. The exposure limits discussed in OET 65 are based on recommendations by the National Council on Radiation Protections and Measurements (NCRP), the Institute of Electrical and Electronics Engineers (IEEE), and the American National Standards Institute (ANSI). The FCC has guidelines and procedures for evaluating the environmental effects of RF emission. Those guidelines incorporate two tiers of exposure limits based on whether

- Exposure occurs in an occupational or “controlled” situation, or
- The general population is exposed, or an “uncontrolled” situation.

**Table 15-1 FCC Limits for Maximum Permissible (MPE) Exposure for Public and Occupational Workers**

| F = Frequency<br>Range in MHz | MPE for General Public                  | MPE for Occupational Levels |
|-------------------------------|-----------------------------------------|-----------------------------|
|                               | S = Power Density in mW/cm <sup>2</sup> |                             |
| 0.3 - 1.34                    | 100                                     | 100                         |
| 1.34 - 3.0                    | 180 / F <sup>2</sup>                    | 900 / F <sup>2</sup>        |
| 3.0 - 30                      | 180 / F <sup>2</sup>                    | 180 / F <sup>2</sup>        |
| 30 - 300                      | 0.2                                     | 1.0                         |
| 300 - 1500                    | F / 1500                                | F / 300                     |
| 1500 - 100,000                | 1.0                                     | 5.0                         |

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**Note:** Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment, provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply, provided he/she is made aware of the potential for exposure.

RF Energy or Electromagnetic Radiation (EMR) is a type of non-ionizing radiation that has been defined as a physical hazard by OSHA in 29 CFR 1910.1020(c) (13). The main effect of RF/EMR exposure is heating, similar to water or food being heated in a microwave oven. However, exposure is non-accumulative if exposure is kept below the body heating damage range (around 40-40.6°C (104-105°F)). Depending on frequency, the ability of RF energy to heat varies greatly. Even in the cases of severe exposure to high energy levels, if an individual removes himself from the RF environment, the human body will cool itself through biological processes in a relatively short period of time.

Because antennas are placed at a significant height above the ground (especially when if mounted at the tops of poles or other tall structures or within the allotted communications space on a pole or structure), the exposure of the general public to RF radiation is not usually of concern. However, industry best practice is that all installed antenna elements should be presumed to be energized and radiating RF energy by utility personnel unless it can be definitively established and verified that the energy source to the antenna has been disconnected. This practice also includes situations where damage to pole structures is caused by natural or human incidents (weather, vehicle collisions, etc.).

### 15.2.2 OSHA Exposure Regulations and Guidelines

**OSHA Requirements** – The Occupational Safety and Health Administration (OSHA) has Section 1910.268 for communications workers, and within that regulation it sets forth safety and health standards that apply to the work conditions, practices, methods, operations, installation and processes performed at telecommunications centers and field work locations.

Several sections of this OSHA regulation address the RF exposure and provide requirements should worker exposure levels exceed acceptable levels:

#### **1910.268(a)(2)(i)**

For normal environmental conditions and for incident electromagnetic energy of frequencies from 10 MHz to 100 GHz, the radiation protection

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guide is 10 mW/ cm<sup>2</sup> (milliwatt per square centimeter) as averaged over any possible 0.1-hour period (6 minutes).

**1910.268(p)(2)**

Hazardous area. Accessible areas associated with microwave communications systems where the electromagnetic radiation level exceeds the radiation protection guide given in §1910.97 shall be posted as described in that section. The lower half of the warning symbol shall include the following text: “Radiation

in this area may exceed hazard limitations and special precautions are required. Obtain specific instruction before entering.” From the referenced OSHA 1910.97(a)(3), the warning symbol for radio frequency radiation hazards is defined to include a red isosceles triangle above an inverted black isosceles triangle, separated and outlined by an aluminum color border. The words “Warning - Radio-Frequency Radiation Hazard” shall appear in the upper triangle.

**Note:** This 1910.97 OSHA rule includes a reference to ANSI Z53.1, Safety Color Code for Marking Physical Hazards and the Identification of Certain Equipment.

**Figure 15-2 RF Hazard Warning Sign**



**1910.268(p)(3)**

Protective measures. As part of the RFSP, when an employee works in an area where the electromagnetic radiation exceeds the radiation protection guide, the employer shall institute measures that ensure that the employee's exposure is not greater than that permitted by the radiation guide. Such measures shall include, but not be limited to, those of an administrative or engineering nature or those involving personal protective equipment.

**Note:** Such measures can include limiting the duration of exposure, de-energizing the RF source, or using PPE to enhance shielding for persons.

### 15.2.3 Radio Frequency Safety Programs (RFSP)

Having an RFSP is essential for entities who have or manage RF antennas mounted on utility poles, as well as for pole owners and other joint users of the pole. For the aerial worker on a pole, the information concerning the potential for RF exposure should be provided, and the means to assure this transfer of knowledge should be addressed in the RFSP.

It is in the best interest of the wireless operator to have an RFSP for individuals who need to work in the vicinity of their plant. The information on hazards introduced by the antenna installations should be supplied through product literature and pole labels and be disseminated to the pole owners and other joint-users of the structure. The pole owners may often be the most efficient communications channel to reach all joint-users of the pole or structure. All owners of equipment mounted to the pole and on aerial strands adjacent to the pole should have means for their individual NOCs to inter-communicate efficiently.

FCC calculations and OSHA/NESC guidelines all assume and emphasize the need for the worker to be “*Fully Aware of the Potential for Exposure*”, with a critical requirement to make workers aware of the presence of radiating antennas and distances from the antenna where exposure levels may be exceeded (through posting of information on the pole), along with adequate training of an individual worker. The general objectives of Rule 420Q are also best met with an appropriate RFSP for the site that should be followed in order to:

- A. Communicate with the NOC for information on site-specific emission and exposure information relevant to the RFSP. The NOCs of other joint users (e.g., power and wireline communications utilities) should also have a means of communication with the Wireless NOC for additional information or shutdown requests, if required.
- B. Help ensure that adequate information is provided by markings on the pole and in the vicinity of the wireless equipment to permit workers to take appropriate actions.
- C. Ensure that technicians who have RF meters use them to verify RF exposure levels at the work location.

Guidance on procedures and protocols to manage and minimize potential exposure to RF radiation in the vicinity of wireless equipment can be found in several documents, including:

- FCC OET Bulletin 65, which provides guidelines for determining if the RF emitting antennas are compliant with FCC guidelines for human exposure. It is not intended to establish mandatory procedures, and other methods and procedures may be acceptable if based on sound engineering practice.

- CFR- Title 47 Part 1 Section 1310 (47 CFR 1.1310), *FCC Radio Frequency Radiation Limits*.
- FCC LSGAC, “A Local Government Official’s Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance,” 2000.
- IEEE C95.6-2002, *IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields*.
- IEEE C95.7, which details the IEEE-recommended practice for Radio Frequency Safety Programs (RFSP), 3 kHz to 300 GHz, based on IEEE C95.1-1992.
- IEEE 1654, *Guide for RF Protection of Personnel Working in the Vicinity of Wireless Communications Antenna Attached to Electric Power Line Structures*. The IEEE 1654 guide is under current revision and presents information on establishing an effective safety program to help ensure compliance with the applicable regulations for RF protection of utility personnel working in the vicinity of wireless communications antennas adjacent to, or attached to, utility poles and structures. The guide also provides information on RF Personal Monitors (RFPMs) and RF protective clothing.

#### 15.2.4 RF Exposure Analysis

There are several factors to be considered when determining whether a potential exposure hazard could exist with respect to a given transmitting antenna, including:

- Worker position – Where shall the worker be positioned relative to a given transmitting antenna? Distance from the antenna is an important exposure variable, as the RF energy drops off rapidly as distance from the antenna increases.
- Frequency – What is the frequency of the RF signal being transmitted or emitted? Certain frequency ranges cause more rapid tissue heating than other frequencies.
- Power and Exposure Levels – What is the operating power of the transmitting station and what is the actual power radiated from the antenna? Radiated power is often specified in terms of “Effective Radiated Power” or “ERP”. Radiated power, along with the emission pattern, are primary determinants in calculating the distance from the antenna where RF levels exceed exposure levels.
- Duration – How long would the exposure to the RF signal be, at a given distance from the antenna?
- Cumulative Exposure – What other antennas are located in the area, and what is the exposure from those antennas?

For any aerial work near antennas, the RFSP will need to be followed. For example, if the RF radiation exposure is above the OSHA/FCC exposure

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limits at that point where the work is taking place, the RFSP may include required procedures to have the antenna powered down at the control box or remotely from the wireless NOC. The FCC requires that antenna installations have calculated RF levels below the general population exposure levels at locations where the general public may be exposed (i.e., at 7 feet above ground level). For the utility or other workers who are required to work in closer proximity to the antenna (such as when climbing the pole, or working at an elevated height adjacent to the antenna), they will need to be familiar with their applicable RFSP that should include:

- Information concerning radiation characteristics of the antenna and/or distance from the antenna where FCC exposure limits are exceeded
- Required work practices that involve directly measuring and monitoring RF exposure levels during the work tasks through the use of RF monitoring instrumentation.

The RF radiation characteristics of the antenna will need to be provided by the operator/owner of the antenna and the wireless service (through the NOC) since that entity is the only one with accurate data on the power, current, frequency and associated characteristics of any specific facility, or access to studies of calculated RF emissions of a specific antenna.

The antennas used for cellular transmissions may be located on towers, poles, water tanks or other elevated structures, including rooftops and the sides of buildings. At a given cell site, the total RF power that could be radiated by the antennas depends on the number of radio channels (transmitters) installed, the power of each transmitter, and the type of antenna, as well as the “reach” or range required for a particular base station. The antennas employed to transmit these RF signals typically have directional radiation patterns in the elevation plane, and do not radiate the signal directly in a downward direction, (other than a few degrees of mechanical or electrical down-tilt). In the case of sector (panel) antennas, the radiating pattern is fan-shaped, like a wedge cut from a pie. However, whip style antennas may be employed in the field on poles. These antennas have an omni-directional emission pattern, which radiates RF energy downward. For antennas installed inside of enclosures, the type of antenna and its associated emission pattern cannot be assumed without antenna-specific information.

The power density from the antenna decreases rapidly as one moves away from the antenna. Consequently, ground-level exposures at the base of the tower or pole are much less than exposures if one were much closer to the antenna. The necessary “keep-away distance” can vary greatly depending on the actual number and power of individual channels transmitting at any one time. As new antenna equipment and wireless technologies are advancing, it is difficult to give definitive guidance for the non-wireless workers approaching a pole (or structure) without detailed knowledge of the specific antenna design and possible multiple wireless carriers who may be located on the structure.

A customized analysis of the RF levels surrounding a specific antenna needs to be performed in order to determine the distances from the antenna where exposure levels are exceeded, and the appropriate marking required (see [Section 15.3](#)).

The software analysis of RF emissions used by antenna operators to meet FCC requirements is often sufficient to meet this “customized analysis” need. The RF exposure analysis can be provided by the wireless operator and/or the antenna manufacturer where the knowledge on antenna design, emission pattern and power levels resides.

The applicable FCC mathematical models for assessing compliance, and application of the technical data, come from OET Bulletin 65 and calculate the RF levels at various points around the transmitting antennas. Since antenna operators generally employ these FCC formulas in a very conservative manner, the RF exposure levels at the antenna site will be significantly less than the calculated values.

The results of the calculations shall be

1. Communicated by appropriate warning signs at the pole
2. Communicated to NOC locations of the joint users of the pole.

If the antenna is replaced or modified, or if the transmission power levels or frequencies are modified, the analysis should be re-performed.

**Note:** In Issue 5 of the *Blue Book*, a default safe working distance of 6 feet from an antenna was stipulated based on extrapolations from FCC permitted levels for the existing wireless equipment, which were relatively low-powered antennas. With the more powerful and directional antennas currently being deployed and designed to meet the demands for both universal wireless services and high performance 4G/5G broadband services, that simple default distance is no longer sufficient. It is apparent that a universal default keep-away distance cannot be assumed, and an RF customized analysis, plus appropriate marking ([Section 15.3](#)), is necessary.

In urban environments, high-rise buildings may not only reduce the coverage area for antennas but may create RF exposure issues for public areas inside the tall buildings and rooftops. The RF exposure analysis discussed in [Section 15.2.4](#) will need to include adjacent structures.

One can reduce occupational RF exposure by minimizing and managing the time that an employee, who has been trained in and is aware of RF exposure, is in the immediate vicinity of a specific antenna. However, such time averaging as a means to manage RF exposure for the workforce in the vicinity of an antenna is not a recommended method because of the complexity of accurately and safely measuring the RF exposure level and the exposure time. An exception would be if the worker has an RF personnel monitor that calculates the time-averaged levels, and the worker appropriately wears and heeds the monitor warnings.

## 15.3 Pole Marking and Product Requirements

From the above discussion on RFSP and required information, it is clear that markings on poles with transmitting antennas are critical to providing joint-use workers on the pole with sufficient and clear information on RF exposure levels.

The sections below provide commentary on certain pole markings, product requirements and other sources of information and guidance that can assist in the development of appropriate procedures for the application of warning signage protocols for pole-mounted antennas. Proper application practices of such signage will be able to provide workers accessing the pole with sufficient warning of RF hazards when approaching a pole-mounted antenna.

### 15.3.1 Pole Markings

As part of an RFSP, pole marking or labels are required to inform personnel of RF exposure hazards applicable for transmitting equipment on the pole. Examples of labels and pole markings particularly appropriate for wireless facilities located on joint-use structures can be based on the requirements in Section 12.1 of GR-3171, as follows:

**Pole Marking** – The attaching party (wireless operator or their contractor) should mark the pole with a sign for each antenna installation, as follows:

- Design and signal words conform to established specifications per the latest edition of IEEE Std. C95.2.
- RF energy advisory symbol, text fonts, sizes, and colors per the latest editions of ANSI Z535 and IEEE Std. C95.2.
- An explanation of the RF source (e.g., transmitting antennas).
- Behavior necessary to comply with the exposure limits (e.g., obey all signs and markings).
- 7-day/ 24-hour contact information that would include phone number or email address to help result in a timely response from a NOC, for example.
- A unique identifier of the antenna installation.

From a logistical standpoint and as an option for service providers, the information may be better centralized to the NOC between the two companies. Although not explicitly required by the NESC code, the following practices should be followed and included in an applicable Joint-Use Agreement (JUA) or licensee agreement:

- The RFSP should identify the safe working distances (keep-away distances) clearly, or distances from the antenna where exposure limits may be potentially exceeded or be used to specify a standard

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placement for signs where the exposure limit may be potentially exceeded.

- The RFSP should identify the RF exposure levels.
- When working in the vicinity of communications antennas, workers shall be familiar with the RFSP. The workers should not unnecessarily expose themselves to radiation levels that exceed those set forth by the regulatory Authority Having Jurisdiction (AHJ).
- Since network technologies and wireless equipment are changing fast, the RFSP program needs to include a change control process to keep the training and posted information current.

### 15.3.2 IEEE C95 Practices and Guidelines

IEEE C95.7, IEEE Recommended Practice for Radio Frequency Safety Programs (RFSP), 3 kHz to 300 GHz; IEEE C95.2, IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols; and ANSI standard Z535.2-2011, American National Standard for Environmental and Facility Safety Signage, deal with environmental and facility safety signs.

IEEE has produced several standards under the auspices of the IEEE International Committee on Electromagnetic Safety (IEEE- ICES). IEEE C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, is referenced in OET 65. It discusses RF risk assessment and RF safety programs when dealing with Radio Frequency Energy (RFE) Field exposure, and references IEEE C95.7. IEEE C95.7 talks about the recommended practice for RF safety programs, 3 kHz to 300 GHz, and references IEEE C95.2, which discusses the standards for radio frequency energy and currently flow symbols for signage.

IEEE C95.7 also discusses the use of signs as part of the RFSP referencing IEEE C95.2 and ANSI Z535-1998. ANSI Z535-2 covers the templates for presenting safety and accident prevention information.

**Figure 15-3 RF Energy Advisory Symbol**



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Such a general symbol needs to be supplemented with more informative safety signs with various levels of increasing concern from INFORMATION and NOTICE levels through CAUTION and WARNING signs up to the DANGER condition. All signs are assumed to provide company ownership information for wireless equipment, and appropriate contact information for other workers who need access to joint-use facilities on the pole. The key components of labels for RF hazards are (a) an RF symbol to signify the hazard type, (b) the appropriate color and wording to help establish the level of RF exposure (see below), and (c) specific keep-away distance or guidance from the antenna (emission source).

|                                                                                     |                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p>The Safety Red or Orange with DANGER or WARNING indicates RF exposure levels more than 10 times the acceptable occupational levels for workers.</p>                                                                                                                                                            |
|    | <p>The red DANGER label is usually reserved for situations where there are immediate touch dangers such as electrical shock or burn hazards.</p> <p>Workers must use time averaging to manage their RF exposure unless the device power is reduced or turned off (Lock Out - Tag Out procedures would apply).</p> |
|  | <p>The Safety Yellow background with CAUTION sign indicates a potentially hazardous situation.</p> <p>RF exposure levels above acceptable occupational levels for workers who shall use time averaging of the RF exposure unless the device power is reduced.</p>                                                 |
|  | <p>The Safety Blue background with NOTICE sign indicates RF exposure levels above acceptable levels for the general population.</p> <p>A worker climbing the pole shall follow the procedures of their RFSP.</p>                                                                                                  |
|  | <p>The Green background with INFORMATION may include ownership and contact material as well as general safety practice guidance.</p>                                                                                                                                                                              |

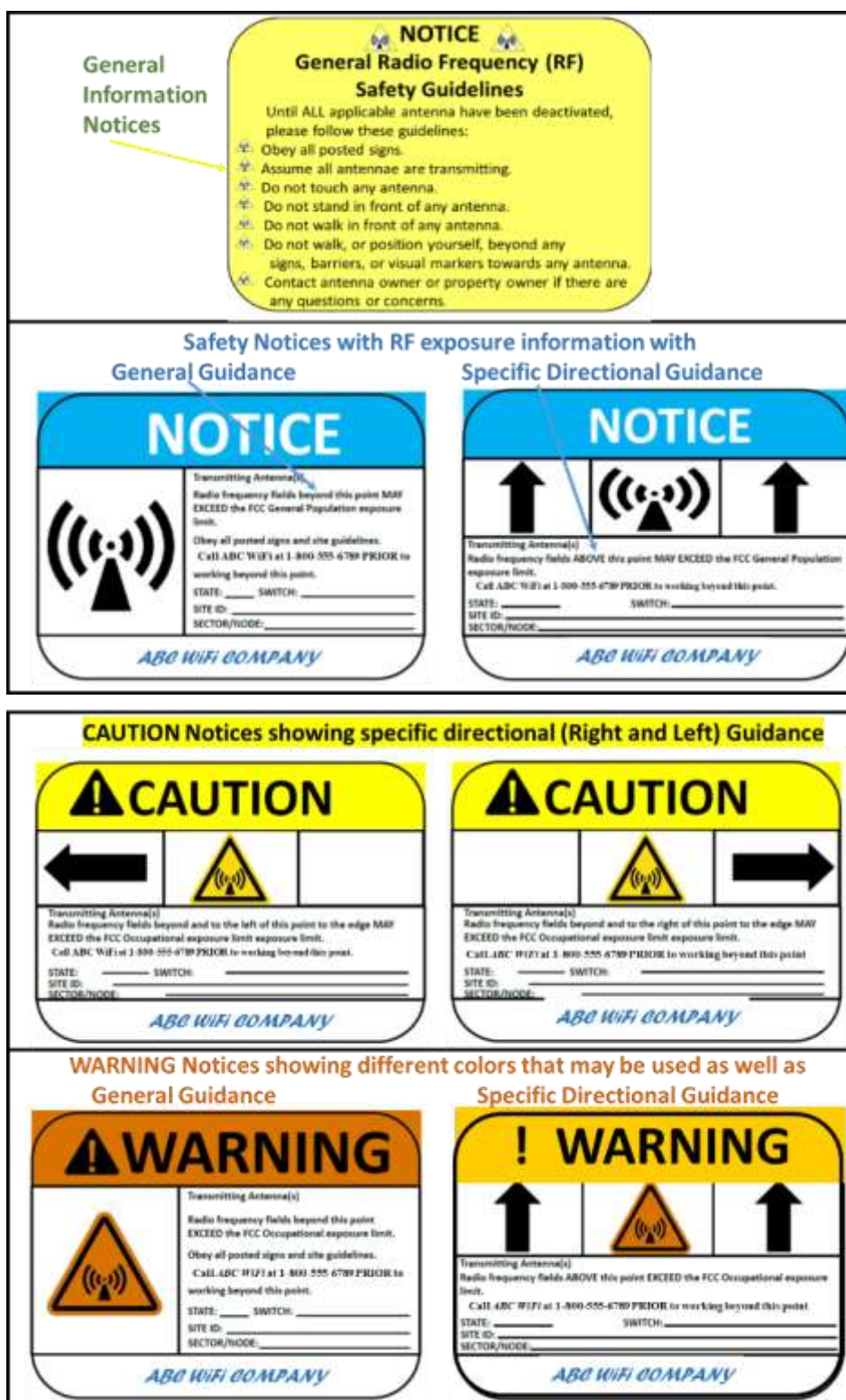
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Using these standards along with sound engineering practices, the RF exposure can be identified, managed, and/or mitigated with the appropriate practices and procedures defined in an RFSP and outlined above. [Figure 15-4](#) gives some examples of the signage showing some of the typical various colors, wording and contact information that may be expected. The precise color and wording may vary depending on local regulations and a company's preferences.

Figure 15-4 RF Signage and Demarcation Examples



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## 15.4 Mechanical, Electrical and Spatial Concerns

There are concerns about the physical congestion on poles with antennas, support closures, and their interconnection cables all competing for space with existing installed communications and power facilities.

- **Working space** – Adequate working space must be provided in and around antennas and associated equipment to enable workers to safely access, maintain and repair the equipment while using standard aerial lift and climbing equipment, and while utilizing all associated Personal Protection Equipment

(PPE). This includes adequate working space for the worker to be able to manage part replacements and repair in a manner that minimizes RF exposure, avoids contact with energized systems, and prevents inadvertent physical contact with heat dissipation fins/heat exchangers.

- **Climbing space** – Adequate climbing space must be provided around antennas and associated equipment to permit access to communications and power plant located below, around and above the wireless equipment. Often, this is best achieved through good design and make-ready work to help keep at least one (preferably 2) quadrant(s) of a pole clear of equipment/facilities from ground level to pole top.

With the growing use of aerial lifts and bucket trucks for aerial plant work, climbing space may be less critical, but working space thereby becomes more important to accommodate the ability and space to maneuver a large bucket device up to the work site.

In addition to climbing the pole and the use of aerial lifts, technicians may also need to use portable ladders to access, maintain and repair copper or fiber terminal closures, as well as service drop wires (loops, service access wires). For such ladder work, the technician will need to place, secure, and climb the ladder in compliance with established company safety procedures and any regulatory requirements for performing this work in a safe manner following NESC Part 4 work rules, OSHA 1910 rules, and internal company procedures (also see [Chapter 2](#) for a discussion on fall protection).

Climbing and working space are also vital in a disaster recovery scenario when climbing structures with harnesses and gaffs may be the more efficient means to safely restore services as quickly as practical. Appropriate work rules (M&Ps) need to be defined and followed for direct work on antennas, attachment arms and associated equipment, as well as for other employees working on adjacent plant.

**NESC Rules** – The most relevant NESC rules that apply to the configuration of the antenna and associated equipment on a pole include:

- Rule 232 – Surface (ground) clearances.
- Rule 235 – Under Rules 235C, 235H and referenced Tables 235-5 and

235-6 with coordinated clearances for wireless specific installations in Rule 238F of the 2023 NESC.

- Rule 236 – Climbing Space considered together with Rule 237.
- Rule 237 – Working Space with related work rules found in 420Q, 431 and 441.
- Rule 238 – (238F in particular) Most pertinent when poles are congested with multiple attachments of, for example, street lights, traffic signals, power lines, and other communications plant. NESC 2023 Rule 238F consolidates clearances for wireless facilities from older 235I and 238 under one rule.
- Rule 239 – Vertical and Lateral Conductors that serve and leave the antenna facilities. Rule 239 is a more appropriate reference than Rule 238 for the cables and interconnection cables to the antenna and the associated equipment.
- Sections 25 and 26 (and Rule 213) – Pole strength and Loading – The additional vertical (weight) and lateral (wind) loading placed on the pole from antennas and equipment should not be large, but still needs to be calculated. As part of the engineering design, the condition of the pole needs to be established and verified during the pre-work survey and make-ready activities prior to any attachment work. The structure shall have no significant decay in the wooden pole; no significant metallic corrosion or rust for metallic towers, poles or composite structure; and be of sufficient strength for adding the new wireless attachments with the appropriate safety factors included for construction grade condition. The various joint users on the pole or structure are likely to have their internal practices, which will help avoid attachment of plant to an inadequate pole or structure. The frequency and details of tests/inspections of the pole condition are covered under NESC Rule 213 and in Chapters 2 and 12 of this *Blue Book*.

Refer to [Chapter 3](#) for detailed discussions on required clearances in general. Some clearance and separation issues of particular relevance for wireless antenna and equipment are discussed below.

### 15.4.1 Ground Clearances

The antenna is usually placed as high as practical to obtain maximum single coverage. The minimum ground clearance requirements of NESC Rule 232 are chiefly applicable to the location of control and power supply closures (boxes).

The NESC references minimum ground clearances for the grounded cases and components of the antenna/wireless systems:

- 15.5 feet over roadways in general with allowances to reduce that distance where vehicles are unlikely

- 11 feet where only pedestrians are likely, or down to 9.5 feet where restricted access under the pole is usual.

There are allowances under footnote 7 of NESC Table 232-2 to place the control boxes lower down as long as they do "...not unduly obstruct a walkway". Closures containing switching and control equipment can be placed lower down on poles (e.g., only 5-6 feet off the ground) to enable access for authorized employees to turn equipment or circuits off before climbing the pole or approaching with an aerial bucket. Such boxes should be locked or otherwise secured against unauthorized entry, and not offer easy foot- or hand-holds for unauthorized individuals to climb higher up onto the poles.

However, for construction and engineering design purposes, most companies have objective ground clearances significantly higher for their planning purposes. For example, minimum design clearances over roads in mid-span are usually 18 feet.

#### 15.4.2 Separation from Supply and Other Communications Lines

The necessary clearance and separation on joint-use poles between power and communications, as well as between communications plant of different companies, are mainly found in subsections of Rule 235 and 238.

- Rule 235C1b = Between supply and communications as specified in Table 235-5 (Row 1a).
- Rule 235C1c = Between communications components (same company and competing communications companies) that references Rule 235H where a 12-inch separation at support and 4 inches in mid-span are the basic clearances.
- Rule 238F = Covers particular aspects for communications antennas and equipment located in the supply space at the top of the pole along with the configuration of the cabling as it travels vertically up the pole and exits from conduit to the antenna facility with cross references to Table 235-6, along with other sections of Rules 238 and 239.
  - Clearances in Table 235-6 of the 2017 NESC and its rows 1c (3-6 inch clearances) and 4a (5-inch clearance) have been relocated to Rule 238F and its tables as well as in Rules 239 and 420Q, which are discussed below.

Rule 235C1(b) points to a basic clearance of 40 inches (compared to 48 inches in GO 95) between the supply and communications lines, with a voltage adder for higher voltage lines ( $> 8.7\text{kV}$ ). The 40-inch minimum should be sufficient unless the wireless equipment is attaching to high voltage lines; even then, the neutral conductor should be the lowest supply conductor for which 40 inches is sufficient. In footnote 5 of Table 235-5, there is some allowance made to reduce the distance to 30 inches, but as a design guideline and choice, the recommendation is to maintain the 40-inch minimum vertical clearance as the de facto minimum design criteria. In

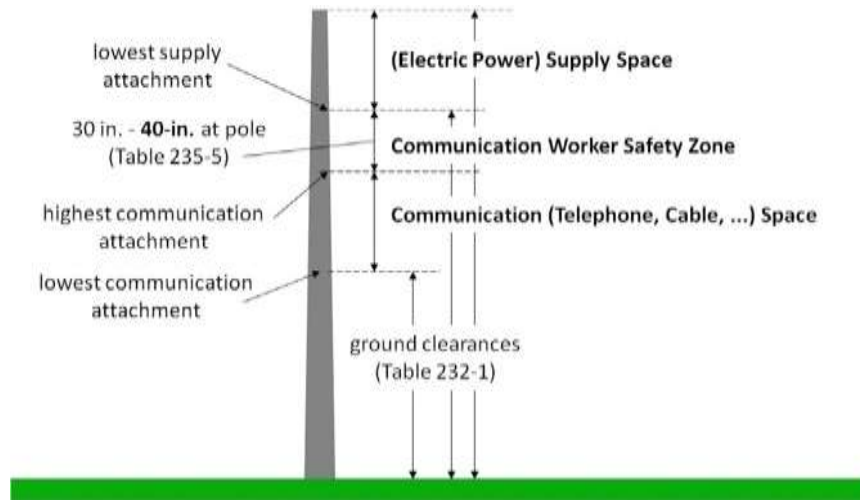
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most circumstances, the 40 inches will be measured vertically from the top of the antenna (usually highest point) to the bottom of the supply equipment.

**Figure 15-5 Space Allocation on Utility Pole**



The 12-inch separation between communications devices at structure and 4 inches in span found in Rule 235H includes communications cable and the support arms of antenna. In some areas, the communications service providers plan ahead and attach their equipment at 52 inches beneath the power facilities with the assumption that if CATV or another licensee attaches later, then the second attacher company (licensee) can go above the incumbent wireline cable and still maintain the 40 inches of minimum clearance.

In the latest edition of NESC (2023), Rule 238F has consolidated the clearances and separations required for antennas and associated equipment in the supply space where antennas are placed at the top of the pole, or on pole extensions, or if the wireless equipment is located in (or below) the communications space attached directly on the pole or offset on sidearms or brackets.

### 15.4.3 Other Clearances and Separations

*(Rule 238 Vertical Clearance between certain communications and supply facilities; Rule 239 Clearance of vertical and lateral facilities from other facilities and surfaces of the same supporting structure; also see Chapter 3 - Sections 3.1 through 3.5 and associated tables)*

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15-24

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NESC Rule 238 covers non-current-carrying metallic supports and brackets and considers antennas to be the same as communications lines and equipment for clearance purposes. Cross references to the 40-inch basic clearance between supply lines and communications equipment is made, along with necessary clearances from communications lines (includes brackets, cables) to luminaries (street lights), traffic signal brackets, and trolley/light rail conductors.

The 40-inch minimum vertical clearance applies to supply line conductors and the top of communications antenna and should also be applied to the separation between antenna support brackets and power conductors. Although parts of Rule 238B/Table 238-1 do permit that the vertical clearance between grounded communications hardware and the bottom of the transformer be reduced to 30 inches, the recommendation that the designed distance be kept at least 40 inches is the preferred better design choice.

General design consequences that can be drawn from application of NESC Rules 238 and 239 to wireless facilities would include:

- Wireless antennas and closures mounted on a pole are to have their brackets and cases grounded.
- Drip and stress-relaxation loops for connection points shall maintain adequate clearance (i.e., a 2-inch minimum or preferably 4-to-6-inch nominal separation) from bolts or other metallic hardware. For these insulated and jacketed cables (supply and communications) that are effectively grounded and bonded, the necessary clearance is simply to avoid abrasion damage or accidental mechanical damage during work activity of any of the employees of the joint users of the pole.
  - The nominal design value of 4-6 inches derives from the following considerations: The mechanical clearances from bolts and hardware to drip loops that are necessary for these wireless attachment cases are greater than the 3 inches in the NESC 238D exception, and the 2 inches of Rule 239G5. However, as a good mechanical design principle, the 3-to-4-inch clearance is a useful minimum value to use. Having such a design principle for attachments to the antenna support arm and antenna will be useful if or when similar antenna hardware is placed in or above the supply space in the future.

For wireless facilities and installations, NESC Rule 239 is applicable to

- Cable connections from control box up pole to antenna are vertical facilities
- Antenna and associated equipment on support arms are lateral facilities with
  - 239A – general features for placing cables in conduits and under U-guards

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- 239B – location of vertical and lateral cables in climbing space
- 239C – conductors not in conduit
- 239D – guarding and protection near ground (i.e., within “ 8 feet of ground or other areas readily accessible to the public...”)
- 239E – for vertical and lateral supply conductors and supply space only
- 239F – requirements for vertical and lateral communications conductors within the communications space
- 239F1 – clearance requirements that point to Rule 238F; i.e., 5 inches of clearance
- 239F2 – clearances from supply conductors > 40 inches as per Table 235-5.

Cable connections from the control box up the pole to the antenna are vertical facilities per the rule. Therefore, placing all these cables in conduit shall help to protect them. As such (cable in conduit), they are not deemed to interfere with climbing space or workspace. They could be attached directly to the pole, but parts of Rules 236 and 237 would necessitate some level of mechanical and electrical protection for supply cables and communications. Placing the run in conduit is a preferred design strategy - from control box to antenna support, and from power connection (transformer/line conductors, meter box) to control box.

Under Rule 239A2d, one company is permitted to run dedicated supply cables (e.g., power for antenna) and communications cables in the same duct or U-guard if everything is operated and maintained by the same communications utility.

However, separate conduits/U-guard are preferred for cable management purposes such as to separate power and communications, as well as to allow controlled access to one cable while not interfering with other cables.

The wires/cables that connect to the antenna and associated equipment on support arm are lateral facilities, and it is recommended that these be enclosed in grooves, tracks or otherwise neatly arranged/attached to parts of any support arms or brackets to avoid the hazards of being snagged by workers climbing by, or when working on adjacent equipment. Having these interconnection cables neatly arranged will help avoid possible mechanical and abrasion damage from wind, rain or incidental contact by persons.

As per Rule 239G, vertical supply conductors and cables passing through communications space on jointly used line structures requires guarding (U-guard or conduit) from 40 inches above the highest communications attachment to 6 feet below the lowest communications attachment.

Guidance on the clearance from bolts and other metal objects of supply cables is to have a clearance of not less than 2 inches from exposed through-

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bolts and other exposed metal objects attached thereto that are associated with communications line equipment. For design purposes, an objective separation of 4-6 inches is desirable based on the discussions on Rule 238 above. In terms of wireless facilities, the NESC 238-239 rules cover the power supply cables running from the transformer/power sources to the meter box and control box for the antenna that are best placed inside non-metallic conduit or under U-guard for protection.

#### 15.4.4 Climbing Space

Wireless attachments, including any equipment enclosures installed in conjunction with antennas/integrated antennas, must ensure they do not interfere with any operational equipment existing on the pole, nor create safety hazards for personnel required to climb the pole or maneuver a bucket or ladder into position to access their equipment. The minimum climbing space requirements in Rule 236 of the NESC must be maintained. This operational equipment includes any supply equipment (e.g., fuse cutouts, disconnect switches) requiring a hot stick or manual operation from the ground or the need for a worker to climb the pole to operate/maintain.

Adequate climbing space shall be provided around the antenna and associated equipment to permit access to all communications and power plant located below, around and above the wireless equipment. Often, this is best achieved through good design and make-ready work to help keep at least one (preferably 2) quadrant of a pole clear of equipment/facilities from ground level to pole top. There also should be considerations for how many risers are currently mounted on the pole and whether they are in positions that will interfere with a climber's belt and its ability to maintain a safe hold on the pole.

With the growing use of aerial lifts and bucket trucks for aerial plant work now, climbing space may be less critical, but working space thereby becomes more important to accommodate the ability and space to maneuver a large bucket device up to the work site. Climbing and working space become vital in a disaster recovery scenario when climbing structures with belts, harnesses and gaffs is the more efficient means to safely restore services as quickly as practical. The frequency, experience and training levels of climbers will vary considerably around the country. There are instances where a pole is in a location remote from a road, or in a position that is difficult to reach, such as in an easement where the equipment can be easily accessed only by climbing or the use of a ladder.

Climbing space (NESC Rule 236) and working space (NESC Rule 237) requirements are premised on several points:

1. Supply and communications workers must have adequate space to:
  - Climb a pole safely
  - Be able to establish a secure and anchored work position with access

to equipment to complete their task safely and efficiently.

2. On a joint-use pole, since the supply worker is normally the one who needs to climb through the communications lines/equipment to reach his/her work position, the supply worker and the supply company are normally the authorities to define if sufficient climbing space is present.
3. Note that the climbing rules of NESC Rule 236 apply only when the worker is climbing the pole. That is, if the worker uses an aerial lift (bucket truck), then Rule 236 does not strictly apply. However, there needs to be adequate space around the facility to bring the aerial lift/bucket safely up to the pole and the work site.
4. Vertical cable runs in conduit are not considered to obstruct climbing space.

Keeping one side of the pole free of communications lines and equipment helps to ensure adequate climbing space as per Rule 236. Keeping one quadrant free from top to bottom is sufficient as per NESC Rule 236 and Figure 236-1, but a good design principle is to have one side free from the ground-line to the supply space. That free quadrant or side for climbing space can move around the pole (NESC Rule 236A3) but it is better, as a design principle, to provide a clear space from the bottom (ground line) to the pole top to avoid debate.

As a design principle, the cable attachments, any antenna support arms and control boxes should be (a) located on one side of the pole, (b) with all the equipment grounded, and (c) the vertical runs of supply and communications serving the antenna being in conduit. Under such circumstances, such an installation would provide adequate climbing space on the other side of the pole and thereby meet the relevant parts of NESC Rule 236 such as Figure 236-1, 236A, 236B, 236C, 236D, 236E, 236G and 236H. If all the equipment is grounded, this assumes that the communications/power ground circuits are bonded together at the meter box, power supply box, or the communications control closure.

Finally, the size of the equipment being attached to the pole must be considered as it will create an obstacle for climbers to pass. Good industry practice is to limit surface mounted equipment to 600 mm (24 inches) in height. Any equipment taller than 600 mm (24 inches) should be mounted on standoff brackets, allowing a recommended minimum of 100 mm (4 inches) between the pole surface and the surface of the equipment, which grants the climber access to use a secondary belt or lanyard to successfully pass the obstruction.

### 15.4.5 Working Space

Adequate working space shall be provided in and around antennas and associated equipment for all workers involved; this includes wireless workers and other communications/supply employees who need space to install, repair, maintain and replace adjacent plant. This working space is achieved through meeting the clearance, separation, climbing space and working space requirements of NESC.

- Rule 237A – Working Space on the climbing face defined under Rule 236 of the pole.
- Rule 237B – Dimensions of working space:
  1. Along support arm --> working space shall be available from climbing space adjacent to the pole to the outer conductor position on the side arm.
  2. At right angles to side arm --> working space shall be available out from the side arm the same as the climbing space of 236E.
  3. Vertically --> points to Rule 235/Table 235-5 where supply facilities shall be at least 40 inches above the antenna. Poles with transformers mounted on them can be a challenge, not only because power workers may need access to that pole more often than other poles, but also because the power workers need to obtain the necessary working space for a climber or aerial bucket. Therefore, it is recommended to avoid placing wireless equipment on poles with transformers. The head of the worker will be into the bottom of the CWSZ (Communications Worker Safety Zone) and his/her feet shall be close to lower placed communications plant.

Applying NESC Rules 237B(1) and (2), the worker should be able to maintain or repair the antenna for the typical various mounting types that often place the equipment less than 2 feet from the pole. The antenna on some mounting configurations have antennas that are ~4 feet from the pole that will probably need an aerial lift (truck) to access and work on effectively.

- Rule 237D – Covers space around buckarms construction that consist of two sets of crossarms at 90-degree angles to each other. Such plant is not a construction normally associated with communications lines or wireless attachments.
- Rule 237C – Requires that vertical and lateral conductors do not obstruct the normal working space for plant.
- Rule 237E – Guarding of energized equipment – Requires enclosing or guarding for equipment “above the top conductor support” or “located on the climbing side of pole”. This rule includes a reference to Minimum Approach Distances (MAD) in the work Rule 441 for electrical workers.
- Rule 237F – Work clearances from energized equipment

These NESC 237E and F rules are focused on supply line conductors and supply equipment as is shown by the explicit reference to the Work Rules of Section 441. The equivalent minimum approach distances for communications workers in particular are found in Rule 431, which are consistent with, or greater than, those of Rule 441. The space and clearances noted with Rule 237 are focused on, and based on, the electrical shock risks and contact hazards.

Sufficient working space for a communications technician working on the antenna should be present without a need to cover, enclose, or otherwise guard the supply facilities that should be at least 40 inches above the antenna. There may be some concerns when the technician is working from an aerial bucket and the due care and consideration needed as that worker/bucket are moved into position to avoid coming within the minimum approach distances of supply facilities as prescribed in Rule 431 (Table 431-1). A supply employee (climber) working on the transformer or supply lines above the antenna needs clearance from the antenna, which should be attainable by the climber by working on the opposite side of the pole in an open climbing zone.

#### **15.4.6 Heat Dissipation**

Heat dissipation from the wireless control boxes or other enclosures may require heat exchangers, cooling fins or other mechanisms that need to be managed and labeled to help avoid accidental worker contacting such hot surfaces or gases.

While climbing past or working on an adjacent piece of equipment, an unexpected thermal shock to an aerial worker may elicit an involuntary motion and thereby create a safety hazard owing to their height above ground or proximity to exposed electrical equipment.

Applicable safety warnings and labels required for operation should be present such as UL Listing labels, electrical hazards, and temperature touch warning labels.

Limitations on the temperatures of touchable surfaces are necessary to minimize this risk. Limits and conditions for testing are based on UL 60950-1/UL 60950-22 and can be found in various GRs including GR-3108, GR-487 and GR-3171.

Labels or warnings should be on equipment parts requiring heat for the intended function (e.g., a heat-exchanger or cooling fans), so that the condition is clear to the general public and service person, as applicable. A warning shall be marked on the equipment in a visible position adjacent to the hot part and shall be either the symbol (IEC 60417 [DB: 2002-10]), or the equivalent warning text such as:

**WARNING!****HOT  
SURFACE  
DO NOT  
TOUCH****15.4.7 Powering and Grounding**

The power needs of the wireless equipment in terms of AC power feeds and DC power from AC/DC inverters will vary considerably with the vertical cabling feeds, including:

- Local grid connection to the power supply box (see [Chapter 14](#)) with subsequent AC or DC power cable to wireless equipment using twisted pairs, stranded power conductors or coaxial cables.
- Power (DC) cable feeds from a pole-mounted enclosure or ground-mounted cabinet that provides both power and backhaul facilities.
- Hybrid power and communications cables to minimize cable runs and conduits on the pole.

The necessary electrical grounding of the system or intersystem bonding to the power ground/neutral will usually occur at the power supply/control boxes associated with the facility. However, incidental bonds and grounds may be required to help ensure that outside closures of wireless equipment are grounded (see Chapters 10, 14 and 25 for further discussions).

It is highly recommended that the small cell antenna and its associated hardware/equipment be bonded to the existing vertical grounding wire on a structure, if one is already in place. This reduces the possibility of having different electrical voltage potentials on the pole, which can compromise the reliability of an existing system, as well as safety. Additionally, wireless equipment manufacturers may require additional grounding/bonding methodologies, beyond those required for safety purposes to ensure proper equipment operation (e.g., RF signal reference grounds).

**15.4.8 Cables and Attachment Hardware**

Communications cables and devices to serve these wireless applications can be mounted and designed using traditional materials, designs and configurations following the aerial or buried rules outlined throughout other chapters of this [Blue Book](#).

Pole- or ground-mounted cabinets or closures should be compliant with GR-487 or GR-771 and/or be IP66 rated. These control and communications cabinets/closures may weigh up to 100 lbs (~50 kg) and contain communications equipment for

- Monitoring and controlling RF power levels,
- Multiplexing of signals, and
- Providing remote alarming/control functions.

The cabinets/closures are usually attached lower down on the pole from the antenna positions to provide more ready access for service and maintenance, i.e., lower down in or below the communications space on the pole as well as possibly placed at ground level where space is available. These closure sizes and weights may decrease as the smaller Femtocells and Dot devices become more widespread.

Smaller, lighter units will have greater flexibility and choices in the placement on poles, strands and other structures.

The pole attachment hardware and closure materials need to be evaluated for weather (rain, wind, ice) and corrosion resistance, and for their ability to maintain a strong bond with the pole or mounting surface under long-term vibration or wind conditions. Any failure or slippage of attachment/mounting hardware can have serious consequences if it leads to equipment falling from, or becoming detached from, a pole and creating a high risk hazard to the public and automotive traffic below. Attachment hardware should be evaluated for these functional performance characteristics against industry standards such as GR-3174, GR-487 or GR-3171.

#### 15.4.9 Attachment Structures

Placement of an antenna as high as practical on the pole is preferred to attain maximum coverage of the wireless signal. The supporting closures and cabinets should be placed lower down in the communications space (or below) to help enable ready access and make equipment maintenance easier.

Depending on the size and weight of the wireless facilities, additional allowances may be required for new wind loading force to the pole. Such wind load effects will be larger for equipment mounted higher on the pole. For antenna and equipment placed lower down on the pole, but located on cross-arms, side arms, or braces, additional mechanical considerations of unbalanced loads and torsional stresses on hardware is needed.

All the mounting and protection hardware should be designed for attachment with two bolts per bracket to help prevent rotation and loosening as well as fitting around the outside of any pole extension pipe or mast. The antenna and cabinet brackets and any associated nuts/ bolts should be designated as either galvanized or stainless steel so as to provide adequate weather resistance for this outside plant application.

In addition, the pole, tower, wall or roof structure needs to be verified to be sound mechanically and able to withstand the added loads and stresses with the appropriate safety factors applied for construction grade condition and situation.

**Figure 15-6 Pole Top Antenna Attachments**



As an example, consider a pole top antenna attached through a pole top extension device. The attachment hardware for any pole top extension hardware will need to be reliable and of adequate quality to ensure long-term securing of the extension pipe or rod to the existing pole. Meeting the requirements of GR-3174 or an equivalent product specification is one way for the attachment hardware product to qualify for this application. If pole top extensions are used to maximize antenna coverage or to avoid congestion lower down on the pole, the health of the existing pole top needs to be established and verified during the make-ready work to help ensure that:

- The pole has no significant decay or defect and retains at least 95-98% of its original (as placed) strength through sound and prod tests as well as boring tests if any concern is found with the sound/prod tests. Although NESC rules would permit lower retention values for the poles (~67-75%), the design imperatives and service expectations of an operator should often set the no-go/go criteria higher at ~90% strength retention or higher.

**Note:** Pole inspection methods and procedures, and the calculation of the remaining strength of a given pole, are found in [Chapter 12](#) of this *Blue Book*.

- The pole top segment from the tip of the pole to 24 inches down is sound and has no significant splits, cracks or decay that would



compromise the pole top extension attachment.

- The existing lines, guys, and aerial hardware can support a reliable attachment of the pole top extension or antenna. For example, if the existing guys and lines are attached too close to the top of the pole, they may need to be moved prior to antenna placement. For wooden poles, design considerations of an assembly with through-bolts and curved washer/nut combinations should be considered for pole top extensions and cabinet/box mounting brackets to help ensure long-term reliable attachment to the pole.

## 15.5 Location Choices for Antenna/Wireless Equipment

One of the primary choices in selecting antenna sites should be to avoid placing antennas on poles or structures with existing serviceable equipment. Examples of such serviceable equipment mounted on poles would include power transformers, power grid switches/breaker devices, splicing cabinets and closures, multiple service drops and fiber cable loops. All these components are likely to be visited or require maintenance regularly by power and communications (wireline) personnel to install new customers, maintain/upgrade networks and repair service drops. The avoidance of antenna installations on such poles not only alleviates congestion of the pole, but also reduces the potential for placing service and maintenance personnel in close proximity to the antenna where the RF exposure is present.

Although the various components of the wireless system meet the definitions of communications lines and equipment in the NESC, the antenna and its support equipment may be located in, or above, the supply space in areas where technicians trained for power space work are required for access and work. Issues may also arise because both communications and supply equipment can be placed in various locations along the pole, e.g., communications antenna and control boxes can move up and down the pole and be above the supply space, while supply switch boxes can be lower down on the pole closer to the ground level.

There will be situations where the planned generic designs cannot be readily applied to the “as found” conditions on an already installed joint-use pole. In such cases, it may be preferable to consider various alternate location options for placing the antenna, including:

- Placing antennas on long support or cross arms to attain clearance
- Placing antennas at the top of the pole or using a pole-top extension
- Replacing the pole in question with a taller pole to get improved coverage and increase clearances (an expensive option)
- Alternate placement such as relocating to a different pole for the antenna attachment, or to a different location

- Installing a new pole dedicated to wireless antenna and facilities. This choice is often unpopular with local communities, municipalities and other authorities having jurisdiction.

The placement of a wireless antenna and its associated equipment on an existing pole is often complicated by the presence of already installed power (primary and secondary) facilities and multiple distribution and drop communications plant of CATV, LEC, and CLEC companies. Other attachments on the pole that can congest and inhibit available space can include street lights, traffic signals, and light rail (trolley) conductors.

Apart from the safety clearances required by the NESC code and the RF exposure concerns already discussed, there are also licensing contract obligations, joint-use agreements, and FCC/PUC regulatory restraints that can remove the availability of certain poles from consideration, as well as prohibit specific space along the pole from use without re-negotiating or amending the license or JUA agreements.

In some urban environments or alleyways, the combination of the number and type of services attached can lead to “boxed” poles in combination with multiple drop and service cables filling the aerial space around the pole. Such congestion can greatly limit the accessible space on the pole or working space for adding wireless facilities, and may require considerations of attachment to brackets or crossarms to attain the clearance necessary.

When the pole space is not readily available, the wireless facility (antenna and/or equipment) may be placed away from the pole surface on:

- Pole Top extensions
- Cross arms
- Brackets.

Side arm brackets and pole top extensions may be required in such circumstances to attain the necessary separations and clearances from other facilities on the pole (e.g., communications plant, power supply facilities, etc.). For such attachment points, lateral (horizontal) forces on the structures from wind and rain need to be considered and added to any pole loading calculations to help ensure that the pole can withstand the expected additional forces along with the necessary safety factors applied.

### 15.5.1 Antenna Placement on Light Poles

With the high and growing demands for wireless service, the location sites may require non-traditional approaches such as placement on rooftops, inside church steeples/belfries, and joint placement on light poles. The challenges and opportunities for such non-traditional placements may be more pronounced in urban environments. For the incorporation of wireless facilities on free-standing light poles ([Figure 15-7](#)), several new concerns need to be addressed over and above the general RF exposure issues and clearances noted in Sections [15.2](#) and [15.4](#), above, including:

1. Clearances for safety and to permit independent maintenance between:
  - Underground power supply circuits for lighting
  - Power feeds to antenna
  - Communications (feeds and backhaul) to antenna.
2. Joint placement of power and communications in the same structure:
  - Inside the hollow metallic or fiberglass poles
  - In a handhole – may require separate handholes as individual access points for power and communications.
3. Community acceptance – Suburban and urban communities, as well as other authorities having jurisdiction (local city or municipality, as well as homeowners associations and condominium board), may have varied reactions - positive and negative - to these configurations that all need to be managed.

The above concerns also arise for wireless-only free-standing poles, as shown in [Figure 15-8](#). If existing poles are heavily occupied, then a wireless-only pole may be used with slack span messenger strand supporting the powering cables and backhaul communications cables needed for the wireless antenna. Guidance on the span lengths, sags and tension for such slack span construction is provided in Chapter 9 (Section 9.6 and 9.7) along with necessary strand data in Chapter 4 (Section 4.5).

In general, the joint placement of power and communications cables in the same conduit or handhole is not recommended. However, if it cannot be avoided, then any joint-buried cable plant should comply with relevant rules of Part 3 of the NESC (as discussed more fully in [Chapter 21](#)). The use of span-powering or FMPS power circuits with communications cables does circumvent the NESC Part 3 separation requirements of AC grid powering and communications cables.

An alternative to slack span deployments, wireless antennas may be placed on free standing (un-guyed) poles served by underground (buried) power and communications cables transitioning to vertical supply conductors and cables passing on the outside of the pole in conduit or up the internal space of a tubular metallic or fiberglass poles.

**Figure 15-7 Wireless Facilities on Light Poles**

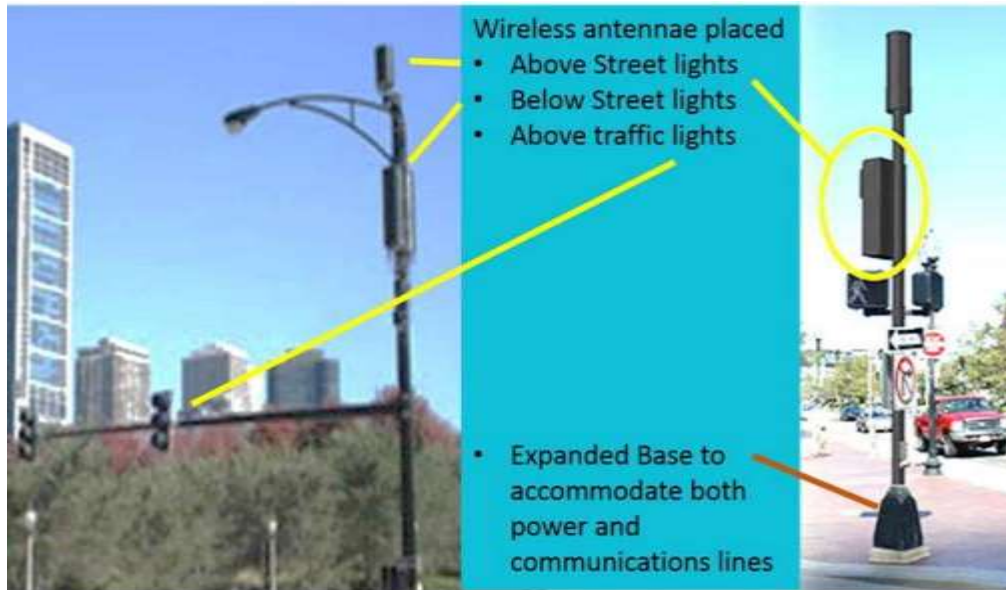


**Figure 15-8 Wireless Self-Standing Pole**

General guidance for these wireless free standing pole configurations and the powering/communications cables that support them would include:

- A. Keeping any power supply voltages below 300 V to avoid additional protection devices and grounding systems (e.g., extra protectors and arrestors) to safeguard personnel in case of a power cross occurring.
- B. To help maintain safe separation and avoid problems, the power and communications cables should be (a) located in clearly labeled (colored) and separate conduits as far apart as practical inside the hollow pole or handhole, and (b) accessed for repair and maintenance through separate ports in the hollow metallic or fiberglass pole. If the access points are handholes, then having two handholes (one for communications and one for power) will help prevent potential problems.

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- A 6-inch minimum clearance should be maintained between supply and communications lines within any jointly used space.
  - Supply and communications cables should be racked or positioned within the access point to allow work on one without movement of the other circuit, e.g., racked on opposite walls or in separate access holes.
- C. Using optical fiber cables or shielded twisted-pair cables to provide communications needs to wireless facilities to help avoid or minimize EMC/EMI problems from the power circuit.
- D. Any vertical supply conductors and communications cables passing up the wireless-only pole or support structure should include guarding (U-guard or conduit) for at least the first 8 feet to physically protect services.

The community acceptance or rejection issues around aesthetic and other perceived concerns concerning property value may often play a much larger role in decisions about allowing deployment of these alternate configurations than any technical or electrical safety concerns for workers or equipment reliability.

## 15.6 Summary

### 15.6.1 General Guidelines

In general, placing antenna higher on the pole will improve reach and coverage area. However, current urban trends are to deploy smaller antennas lower down on the supporting pole or structure to increase ease-of-access and lower initial installation, capital and construction costs. Adequate service coverage is maintained by using more antennas over a given geographic area.

As poles, buildings and structures become more congested with wireless, broadband and Smart-Grid devices and associated equipment, it will become even more critical that proper clearances and separation be maintained around the antenna, its associated equipment and the interconnecting cables associated with these devices.

From an overall perspective, the practical strategy for wireless installations can be summarized as follows:

1. Implement an RFSP that is compliant with current IEEE C95 guidelines or equivalent standards.
2. Design the facility to exceed the minimum clearances and applicable rules of the NESC (see [Chapter 3](#)). The current NESC rules, when properly applied, should provide adequate working and climbing space for the technician as well as the physical protection and separation distances to help ensure reliable operation of the devices. These applicable clearances cover adequate height above ground and

separation from other facilities on the joint-use structure.

3. When communications antennas are deployed at the top of the pole, they shall be installed and maintained only by personnel authorized and trained to work in that electric supply space.

**Note:** Since the top 6 inches of the pole is usually designated as “unusable space” in Joint-Use Agreements (JUAs), the attachment hardware for pole top extensions for the antenna should not be placed into the top 12 inches of the pole. It is generally accepted wisdom that drilling a 5/8-inch or 3/4-inch hole less than 6 inches from the top of a pole and attaching a load through that hole will result in premature splitting of the pole top, thereby significantly shortening the life of the pole.

4. Verify that additional loading on the pole or structure of antenna and equipment are within safety factors and loading criteria of NESC Sections 24-26. All attachment hardware used for antenna, cables, and equipment shall meet GR-3174 functional performance requirements or equivalent industry specifications.
5. All interconnection and powering cables and connections shall have mechanical and electrical protection through the use of protective ducts and conduits that physically cover and guard the cables as well as electrically isolating the cable connections.
6. The antenna owner or operator should supply and post the information on RF radiation emissions for communications antennas along with any applicable signage per standards clearly and conspicuously at the site (see Sections 15.2 and 15.3 above).
  - A. Workers should determine, through information provided on local signage and from their NOC in combination with their company’s RFSP procedures, where the safe working areas are around the antenna. Company policy and worker training shall provide the worker with the capability to determine safe working (keep-away) distances and what RF exposure values are to be applied.
  - B. When working in the vicinity of communications antennas, workers shall follow their company’s RFSP and should not expose themselves to unnecessary radiation levels that exceed those set forth by the regulatory authority having jurisdiction.
  - C. If a calibrated RF meter with time-averaging capability is available, the trained technician shall monitor the RF exposure level in his/her work location during the work activity. If excessive levels are measured or time limits are exceeded, the technician should cease work, move away from the area to an area below General Population levels, and report levels to the NOC.
7. Antenna and equipment mounted in the communications space on the pole should follow the following general principles:
  - A. Any cable (antenna cable or power supply cable) from/to an antenna structure shall travel down the pole in an insulating conduit/duct.

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- B. All cable or connections to the closure shall be contained inside insulating conduits.
- C. The antenna structure or closure associated with an antenna shall be grounded to the power ground (MGN) if present and permitted.
- D. Any cable or connection between the antenna structure and the communications plant in the communications space shall pass through a weather-tight closure/box/cabinet.
- E. Any antenna closure/box/cabinet shall be mounted so that:
  - The bottom of the closure is at least 12 inches above the highest communications cable, and
  - The top of the closure shall be at least 40 inches below the lowest power supply cable, or
  - The top of the closure shall be at least 30 inches below the lowest telecom cable, and
  - The bottom of the closure shall be at least 8 feet above ground level (i.e., the mounting position and configuration shall be consistent with criteria in [Chapter 14](#) of this *Blue Book* for CATV amplifiers and power supply boxes).
- F. Any antenna structure mounted above the communications space shall be at least 12 inches above the highest communications cable, and the top of the antenna structure shall be at least 40 inches below the lowest power supply cable. If this is not possible, then the antenna structure needs to be mounted in the power space by trained supply personnel.

Figure 15-9 below shows some of the more typical locations used for wireless antenna placement on joint-use poles. A detailed review of clearances and separations of the various positions are provided in a 2023 IEEE Guide P2939, *Guide for Joint Use of Utility Poles with Wireline and/or Wireless Facilities*.



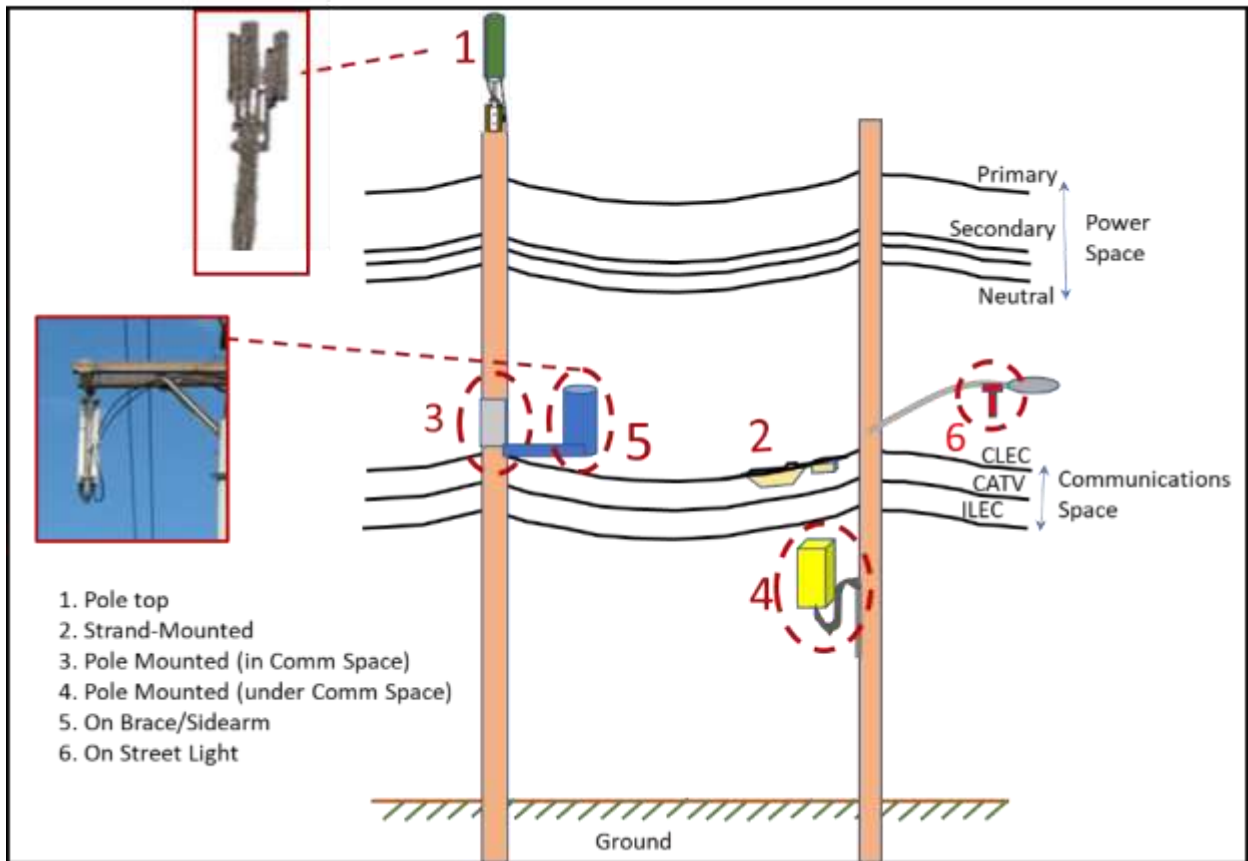
**Figure 15-9 Typical Locations for Wireless Antennas on Joint-Use Structures**

Table 15-2 provides some of considerations of minimum clearances, separations, and other factors that influence the available space on existing poles. These safety and operational factors need to be reviewed for any candidate attachment application from wireless provider. The table contains the candidate locations and pole types for wireless attachments along with generally accepted limitations imposed by utility joint-use pole owners across the USA.

**Table 15-2 Antenna Placement Considerations on Existing Joint-Use Poles**

| Equipment                                                      | Where/What                                               | Considerations (see Note 1)<br>(Clearances and comments)                                                                                                                                      |
|----------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Antenna and related equipment locations<br>(see Notes 3, 4, 6) | Top of Pole (on extension)                               | 40 inches above supply conductors<br>(see Note 2)                                                                                                                                             |
|                                                                | At the top of the communication space                    | 12 inches above comm. cables while maintaining 40 inches below supply or 30 inches below effectively grounded neutral, which defines the communication worker safety zone (CWSZ) (see Note 3) |
|                                                                | Within communication space<br>(on a crossarm or sidearm) | 3 inches horizontal or vertical clearance from other communications lines                                                                                                                     |
|                                                                | Messenger Suspension Strand<br>(strand-mounted)          | 4 inches vertical clearance from other communications lines (cables, equipment, ...) and 18 inches horizontal clearance from the surface of the supporting structure                          |
|                                                                | Below existing communication space                       | 24 inches below lowest communications cable; while also maintaining the minimum required ground or building clearances                                                                        |
|                                                                | Luminaire (Street lighting)                              | 40 inches below supply lines to maintain CWSZ (see Note 7)                                                                                                                                    |
| Number of wireless attaching entities per pole                 | One<br>(see Note 8)                                      | All attachments on same pole must share a single disconnect switch, safely accessible by pole owner and existing attachers                                                                    |
| Pole Framing And Pole Line Configuration                       | Tangent                                                  | Acceptable in some areas (see Note 5) with pole loading analysis to ensure existing guying is sufficient or what additional support is required.                                              |
|                                                                | Angle/unguyed                                            |                                                                                                                                                                                               |
|                                                                | Angle/guyed                                              |                                                                                                                                                                                               |
|                                                                | Dead end                                                 | Not usually acceptable (see Note 1)                                                                                                                                                           |
|                                                                | Junction/crossing                                        | Avoid if possible                                                                                                                                                                             |
| Electric supply lines                                          | Secondary                                                | Acceptable                                                                                                                                                                                    |
|                                                                | Primary $\leq 8.7$ kV                                    |                                                                                                                                                                                               |
|                                                                | Primary<br>> 8.7 kV to 22 kV                             | Acceptable                                                                                                                                                                                    |
|                                                                | Primary > 22kV                                           | Acceptable in communications space                                                                                                                                                            |

**Table Notes:**

- 1 This table describes general criteria. Negotiations regarding attachments to a specific pole or location may be pursued between pole owner and attaching entity based on technical considerations, safety, and operational agreements that can address concerns of both parties.

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- Attachment hardware should meet industry functional performance standards, e.g., the communications industry would use GR-3174.
- 2 The NESC requires a minimum of 16 inches + 0.4 inches per kV in excess of 8.7kV, if located in supply space. See Rule 238F in the 2023 NESC.
  - 3 The NESC requires a minimum of 3 inches separation between the antenna and the highest communication attachment. See Rule 238F in the 2023 NESC. It is recommended that a design minimum of 6 inches be used if practical.
  - 4 These minimum clearances should be increased to provide greater working space and accessibility if desired.
  - 5 Perform load and strength analysis and adjust guying, as necessary.
  6. See detailed NESC clearance rules in Section 235 and Section 238.
  7. See NESC Section 238 for clearances related to luminaire bracket and drip loop. Antenna must maintain a 40 inches clearance from supply lines above to be considered a communication space attachment.
  8. For instances where pole owner may allow multiple wireless attaching entities, all parties physically involved, including the pole owner, must be in agreement.

In addition, if designing for the attachment of a new communication cable, the following assumptions regarding the placement and sag of the new cable attachment are necessary to consider.

- If there are no existing communication cables, the new cable must comply with clearances above surfaces and items below (roads, buildings, ...) as specified in NESC Rules 232, 233 and 234.
- If there is an existing ILEC line, a new third-party attachment will usually be required to be mounted above the ILEC line.
- The pole owner may specify the sag (e.g., as a percentage of span length) or tension, at installation and/or under storm conditions, or the values may be provided by the third-party attaching entity (wireless company).
- Assuming there is no conflict with the other criteria listed in Table 15-2, new communications cables mounted above (or below) existing lines are typically installed to match the sag of the cables below (or above).

With the increase of make-ready work and the quantity of poles/spans that need to be analyzed in a rapid turnaround, time for manual sag calculations is not usually available. Therefore, attaching companies are encouraged to use available software, which includes sag calculators.

### 15.6.2 Grounding and Bonding

The general powering of, and EMC/EMI issues pertinent to, wireless facility equipment includes:

- a. The appropriate grounding and bonding practices for personnel safety and equipment reliability,
- b. The connections to grid power and standby power that meet NEC and NESC code requirements, and
- c. The electrical isolation and surge protection of telecommunications feed cables that enter the local mobile base station from the antenna facilities.

The grounding and bonding requirements of these wireless equipment and antenna facilities shall follow the general principles found in Chapters 10, 14 and 25 of this *Blue Book*. More detailed grounding and bonding configurations and requirements for wireless infrastructure can be found in Section 10 of

GR-3171 covering aerial plant elements (antennas, closures and equipment that is mounted on poles, towers) and ground-based facilities such as cabinets, base stations and other components of the backhaul network.

### 15.6.3 Pole Loading Considerations

*(Also see Chapters 12 and 13 of this Blue Book)*

Pole strength and clearances are two important considerations that may impede the ability to place additional attachments of any type (wireline or wireless) on existing structures, sometimes requiring replacements by taller and/or stronger poles. Whereas clearance issues may often be resolved by make-ready work, potential strength issues are more difficult to address.

Usually the additional vertical (weight) and lateral (wind) loading placed on the pole from antenna and equipment should not be significant. However, the condition of the pole needs to be established/verified prior to attachment to help ensure that there is no significant decay in the pole, it has sufficient remaining strength for the new attachments, or other safety-related concerns (sound and prod tests and/or boring tests).

Antennas placed on side arms and braces can introduce added stresses that need to include consideration of wind loads and torsional stress on attachment hardware (bolts, nuts and arms). Pole loading calculations, as well as the appropriate level of pole strength required (remaining), will need to follow a mutually agreed upon process between all pole users.

Antenna packages may also be mounted in mid-span on strands and messengers. Such locations are required to meet NESC Section 23 separation and clearance distances from adjacent cables - both distribution and drop (service) cable runs. The minimum clearances and separations of

applicable safety codes (NESC, GO95 or local JUA values) need to be met under all expected weather conditions of temperature, ice and wind conditions.

Structures must be analyzed or considered in accordance with the relevant or regulatory (e.g., state PUC/PSC) requirements—typically the NESC or California General Order 95. The Joint-Use Agreement (JUA - see Chapter 26) should provide additional related information, if any, on the pole owner's requirements.

NESC Rule 250B (Combined ice and wind district loading) represents the traditional basic loading requirement and imposes loads on the pole and its supported facilities, as appropriate. For a given loading district, an appropriate wind load is applied to cables and wires, including ice when required, and to the pole and supported equipment, without ice. In cases where the structure or attachments exceed 60 feet above ground level, the loading in NESC Rule 250C (Extreme Wind Loading) and NESC Rule 250D (Extreme Ice with Concurrent Wind) must also be considered.

Additional loads owing to the antenna systems will vary, depending upon the size (dimensions) and location (pole-top, crossarm/sidearm, strand-mount, ...) of the antenna and auxiliary equipment, including cable attachment. Structures should have a load study conducted, as necessary, to help ensure the equipment can be installed without affecting the reliability of the structure, existing attachments, and the safety of both the public and the workers who may be operating near or on the structure.

#### **15.6.4 Attachment Hardware**

The support hardware for attaching (a) control boxes, and (b) antenna support arms to poles, walls, rooftops and other structures need to not only be able to hold the vertical weight of the equipment, but also must be:

- Corrosion resistant for long-term performance in salt fog/pollution conditions, rain, ice and temperature swings
- Robust to withstand the mechanical stresses associated with winds, rain storms, hurricanes, car impacts, local vibrations, and earthquakes
- Resistant to the effects of torsion stresses. In some configurations, equipment on support arm segments is used to obtain sufficient separations from cables and other equipment. In such cases, the forces on the cross arms and braces can become unequal and create significant torsional stress on the attachment hardware.

**Figure 15-10 Example of a Cross Arm Antenna Attachment**

The use of support struts or braces are advisable particularly for the single sidearms or support arms where the antenna is located far out from the pole surface (i.e., 30- 40 inches off pole surface). If support struts or braces are used, they should be angled from the antenna support arm downwards at an angle to the pole. If placed as a hanging brace attached to the pole above the antenna support arm, then this will encroach on the 40-inch vertical clearance distance required to the supply facilities above.

## **15.7 Normative and Informative References Related to Wireless Facilities**

The product procurement issues and the appropriate functional performance requirements for these wireless products and associated hardware are found in a series of inter-related and harmonized GR documents, including those listed below.

### **Wireless Facilities - Infrastructure**

- GR-3171-CORE, *Generic Requirements for Network Elements Used in Wireless Networks Physical Layer Criteria* – Baseline document covering wireless infrastructure components with several complementary GRs (e.g., GR-3031, GR-3032, GR-3033, and GR-3178) to help the application of GR-3171 and its referenced GRs and industry standards to the large, possible variety of wireless configurations, network architectures, and equipment locations that are found. GR-3171 and GR-1089 include limits on emissions to help prevent EMI/RF interference to other equipment (wireline and wireless

facilities of other communications companies) and facilities in the vicinity.

- Requirement **R1-1 [1]** in GR-3171 specifies that the manufacturer provide information and analysis so that “*Wireless equipment shall conform to the relevant emission standards in ANSI, FCC Bulletins 65 and Part 15, UL standards, GR-1089, and other applicable specifications*”. Such a requirement would be met through the generation of the RF exposure analysis discussed in [Section 15.2.4](#) of this *Blue Book*.

## Equipment - Environmental and Physical Protection (NEBS)

- GR-63-CORE, *NEBS™ Requirements: Physical Protection* – Central Office Equipment - Baseline requirements for the environmental, fire resistance, and other physical needs for CO and protected applications.
- GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment* – Functional requirements for equipment to help ensure that the equipment has adequate electrical protection characteristics for the necessary EMC and EMI environment into which the equipment is installed and placed.
- GR-3108-CORE, *Telcordia Generic Requirements for Network Equipment in the Outside Plant (OSP)* – The equivalent of GR-63 for equipment placed in the various outside plant environments and closures.

## Attachment Hardware

- GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*, provides requirements for general pole attachments and includes material and functional performance tests (also see [Chapter 5](#)).

## Governmental Documents - OSHA and FCC Related

- OSHA Standard 1910.268 covering communications workers under Subpart R for Special Industries – 29 CFR 1910.268, “Telecommunications Industry”.
- OSHA Standard 1910.097 covering general rules under Subpart G for Occupational Health and Environmental Control – 29 CFR 1910.097, “Non-Ionizing Radiation”.
- OSHA Standard 1910.269 covering power workers under Subpart R for Special Industries – 29 CFR 1910.269, “Electric Power Generation, Transmission, and Distribution”.
- OSHA Toxic and Hazardous Substances – Definitions; Toxic substance or harmful physical agent. 29 CFR 1910.1020(c) (13),



- FCC Bulletin 65 ([www.fcc.gov](http://www.fcc.gov)) - OET Bulletin No. 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields”.
- CFR- Title 47 Part 1 Section 1310 (47 CFR 1.1310), FCC Radio Frequency Radiation Limits.
- FCC LSGAC, “A Local Government Official’s Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance,” 2000.
- FCC Pole Attachment Act of 1978 - Title 47 US Code 224.
- FCC “A Local Government Official’s Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance,” (LSGAC) 2000.
- FCC - DA-10-893A1 – Public Notice - States that have certified that they regulate Pole Attachments
- FCC 11-50 Report and Order on Reconsideration – Improved Access to Utility Poles.
- FCC Rulings 18-111, Accelerating Wireline and Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment (One-Touch Make-Ready).
- FCC Ruling 18-133 , Accelerating Wireless and Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment. (Small Cell Order).
- ANSI Z535 Safety Alerting Standards
- FCC 19-126, Changes to Rules regarding Human Exposure to Radiofrequency Electromagnetic Fields.
- General Order 95 (GO 95), Rules for Overhead Electric Line Construction. State of California, Public Utility Commission (CPUC),
- Telecommunications Act of 1996, Public Law 104–104, 110 Stat. 56, February 8, 1996.

## IEEE Standards

- IEEE 1654 Guide for RF Protection of Personnel Working in the Vicinity of Wireless Communications Antenna Attached to Electric Power Line Structures.
- IEEE Standard 802.11 – IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

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- IEEE Std 802.16 , IEEE Standard for Air Interface for Broadband Wireless Access System

**Note:** Currently (2023), some of the standards published by the IEEE-ICES are available at no cost through the IEEE GetProgram: <http://standards.ieee.org/about/get/> )

### **ATIS (Alliance for Telecommunications Industry Solutions) Standards**

- ATIS-0600030 “Line-Powering of Telecommunications Equipment on Outside Plant (OSP) Copper Twisted Pair Loops”,
- ANSI/ATIS-0600337, Requirements for Maximum Voltage, Current, and Power Levels in Network-Powered, and
- ATIS-06000040, “Fault Managed Power Distribution Technologies – Human Contact Fault Analysis”.

## 16 General Precautions and Work Rules for Manholes

### 16.1 General

This section covers general precautions and work rules that qualifying personnel (i.e., trained and authorized) who are assigned to work in communications manholes should be familiar with. Other precautions and requirements are stipulated in the License Agreement between the communications company and the licensee occupying the communications company's conduit system. The requirements and precautions covered in the License Agreement [attachment agreement or Joint-Use Agreement (JUA)] must be adhered to even though they are not specifically listed in this section.

The purpose of these precautions is to minimize the possibility of injury to craftspeople and damage to the facilities in the manhole.

Unless otherwise stipulated in the License Agreement, a communications company manhole may not be opened, and no craftsman shall enter or work in a manhole, unless an authorized communications company representative is present.

Rearrangement of communications company cable sheaths, splice closures, and apparatus cases can only be done with the approval of a communications company representative.

#### 16.1.1 Handholes and Other Vaults

Handholes are plastic or concrete structures set below-ground with their lids flush to the surrounding soil, turf, footpath or road surface. Other vaults for cable splicing and equipment can be part of the foundations of concrete pad-mounted cabinets. These enclosures are usually shallow (e.g., 12 to 36 inches deep) compared to manholes and are used to:

- House and protect copper, coaxial, and optical fiber telephone cable splices
- Provide convenient access to and safeguarding of cable termination and branch points
- Provide flexibility and access for installation operations (e.g., pulling or blowing cables).

These below-ground enclosures provide mechanical and environmental protection for the splices contained within, allow access for craftsman work activities, and discourage access by unauthorized persons. See [Chapter 21 \(Section 21.5\)](#) and [Chapter 27](#) for further discussions on work performed inside pedestals and handholes used as access/splice points for buried/underground plant; and [Section 21.2.10](#) on Buried Duct Networks (BDNs).

## 16.2 General Precautions and Work Rules

The following list defines the general precautions and work rules that must be observed when working in and around manholes.

- All persons involved in manhole operations must know and comply with the requirements and have appropriate gas detectors set forth in [Chapter 17](#).
- Before entering the manhole, test the atmosphere as described in [Chapter 17](#).
- Ventilate the manhole before entering, and maintain ventilation continuously while a craftsperson is in the manhole, in accordance with [Chapter 17](#).
- Use a ladder to enter and leave a manhole. Do **not** use cables as steps.
- Do not use open flames in the manhole or in close proximity to the manhole even if tests indicate the atmosphere is free of gas.
- When pulling a cable, be sure sheaves, wheels, and other equipment are secured in a position that will prevent any equipment or pulling lines from contacting the existing cable.
- Spark-producing equipment like meggers, electric drills and impact tools, or induction sets are not permitted in the manhole. An exception to this rule is for electric drills and impact tools designed without commutators (rotary components) that greatly reduce or eliminate electric arc occurring (e.g., many of the modern battery-powered drills).

**Note:** Also see [Section 27.2.3](#) on the use of fusion splices for optical fiber plant in Cable Entrance Facilities (CEFs), manholes and similar confined spaces.

- Planks or other types of platforms shall not be installed using cables as a means of support. When a platform is required, supports can be attached to the cable racks.
- The liquid used to detect leaks in cables that are under air pressure must be approved by the communications company. This is necessary to prevent the use of solutions that may damage cables having a plastic sheath.
- Cable lubricants must be approved by the communications company. This is to prevent the use of solutions that may damage cables having a plastic sheath.
- Except for protective screens, no cover shall be placed over an open manhole unless it is at least 4 feet above the surface of the manhole opening.
- Upon completion of the work, all unused materials, wire clippings, cable sheathing, tools, and debris shall be removed from the manhole.

- All cables and associated equipment installed in a manhole shall be properly racked, clamped, or supported to the satisfaction of the responsible representative of the communications company.
- The storage of surplus or excess coils of a licensee's cable in a manhole requires communications company approval.
- Smoking in manholes or above ground in close proximity to manholes is prohibited.
- Combustible material shall not be allowed to accumulate in the manhole.
- Cables shall be identified as covered in [Chapter 19](#).
- Ducts shall be sealed as covered in [Chapter 20](#).
- Where artificial lighting is required in a manhole, the bulb shall have a protective covering to minimize the possibility of breakage. If an infrared lamp is used, the lamp shall be the heat-resistant type. All lights must be approved by the communications company for manhole use.
- The bonding of the licensee's cable shall comply with [Chapter 18](#).
- Ductliner (innerduct) sealing shall comply with [Chapter 20](#).

### 16.2.1 Power and Communications in Manhole/Handhole

In general, best practice is to have separate manhole (or handhole or pedestal) for AC power company lines, splices and facilities. Using separate closures ensures that the underground communications cables are not exposed to power contact, although indirect exposure to power lines is possible because the communications cables can become part of aerial or joint buried plant. The maintenance of electrical continuity through bonding schemes in Section 18.4 [*Connection to Ground (Earth)*] provides adequate protection in the underground manhole where the bonding scheme includes a connection to the manhole grounding system.

If communication cable is an all-dielectric fiber, cable, and components, then joint-use installation is acceptable under certain conditions, but not a recommended installation owing to concerns with having communications technicians in a hand-hole in close proximity to power. If the shared manhole has communications copper cable, there are additional concerns around possible electrical hazards such as arcing and ac induction.

In the unusual case of them both being present in a manhole they should be separate by a barrier or mounted on opposite walls to avoid any confusion. The following conditions shall be met for an installation with power supply and communications facilities located within the same manhole or vault:

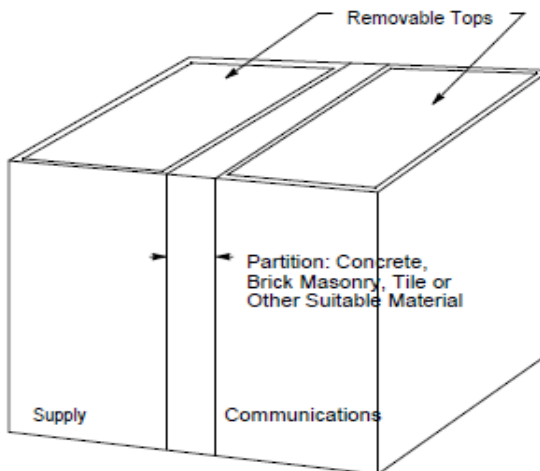
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- The manhole cover shall be marked *Buried Power and Telecommunications Cables Call Before Digging*
- All metallic cable strength members or tracer cables shall be properly bonded and grounded. The maintenance of electrical continuity through the bonding schemes identified in Section 18.4 provides adequate protection.
- Separate conduits shall be used for power and telecommunications cables
- A physical non-conducting barrier such as concrete or fiberglass shall be provided between for power and telecommunications cables
- Facility owner shall have documented Methods and Procedures (M&Ps) for technicians working in the manhole/vault that has both power and communications cables. M&Ps should include
  - Proper testing procedures with a voltage detector to detect foreign voltages on cables, equipment or grounding hardware.
  - How to distinguish each cable type in the shared closure.
  - Proper installation directions for handhole construction including the required barriers and use of separate conduits.

**Figure 16-1 Joint Use Handhole (power-supply/communications)**



These joint-use manholes will need to follow not only the best practices for gas testing, use of an explosive meter (LEL Detector), and ventilation, but also the confined space practices from NFPA 70E (section 130) that may include the use of:

- Protective shielding from energized cables

- Clear working space (6 feet without a barrier)
- Appropriate personal protective equipment (PPE)
- Methods and procedures and training to mitigate the enhanced risk in joint use manhole. The dangers of arc flash events and direct electrical contact are the main reasons that joint-use manholes (power and telecommunications) have generally been avoided.

In general, power supply units and amplifiers used in authorized licensee arrangements will not be installed in manholes. If an exception is required for such in-line amplifiers, communications company approval must be obtained along with conformance with the definition of power circuits used solely for communications equipment (see NESC definitions of communications equipment and lines with reference to Rules 334).

An alternative approach for joint installation of communications and power cables in common direct-buried trench or underground system is to use Buried Duct Networks (BDN) – see Section 21.2.10.

### 16.2.2 Corrosion in Manholes

Evidence of corrosion on metallic hardware, grounding/bonding conductors or the ground rods can indicate corrosive soil conditions, a grounding problem, or a contamination issue. If repeated or persistent corrosion problems are found, including corroded wires or rusted Unistrut, or excessive noise reports of lines occur, then observations in the manhole should be made and reported to the supervisor or the relevant engineer [e.g., the Inductive Coordination and Electrical Protection (ICEP) Engineer] for the site. Relevant items would include:

1. Is ground water routinely present in the manholes? If so, is there visual evidence or odors that show if water is contaminated with gasoline, fuels, biological or other contaminating materials? This evidence would include an oily or colored film on the water surface or excessive turbidity shown as heavy particulate load in water.
2. Are there any distinctive odors in manholes? For example:
  - A smell of natural gas in the manhole which may not be easily purged by the ventilation procedures described in [Chapter 17](#) may indicate a gas line break (see [Section 2.8](#)).
  - An odor like “rotten egg” (i.e., H<sub>2</sub>S) may indicate sulfide producing bacteria are active in the manhole, particularly if secondary indicators of these bacteria such as discolored plastics (e.g., gray PVC cable jackets and orange tags may turn black).
3. Review the surrounding area to note if recent or current problems with adjacent utilities - water, steam pipes, sewerage and drain lines - have

occurred as evidenced by ongoing utility operations, new patches on road, or recent excavations in the area.

4. Note where corrosion is more and less apparent - which metallic components are showing the most corrosion - lead sheaths, steel frames and support hardware, aluminum shields, copper wires, nuts/bolts sealing splice closures, etc.
5. What grounding system is present - a ground ring or a single/group of ground rods. A review of the grounding connection (grounding wire, termination and top of the rod) may be all that can be reviewed without excavation. Check that electrical bonds are tight, are of correct size and design type, and are not covered with excessive corrosion salts.

If the technician has the tools and knowledge, quantitative measurements can be valuable to report. For instance:

- The pH (acid or alkaline) or the electrical conductivity of the water – Ground water can be contaminated with various salts and ionic species such as chlorides and sulfates that can arise from surrounding soil, road salts and other local environmental sources. Groundwater with high conductance (high conductivity) will help accelerate any galvanic corrosion processes that occur.
- Any measurements of the voltages to ground of the various metals present – Steel and aluminum shields, steel rebar, steel support hardware, copper ground conductor, lead sheaths, metallic closures, etc. These potentials can often help tell one about the condition of the metallic finishes and protective coatings on these metallic components.
- Stray current measurements moving through the shields and grounding conductors – If stray currents are found in excess of 20-50 mA, then one needs to review the surrounding area for possible sources such as light rail systems, subway lines, or DC power systems in the vicinity of the plant. The presence of high-voltage AC power lines in the vicinity (i.e., within 500 feet) may also contribute to induced currents and accelerated corrosion.

The combination of such visual observations with quantitative measurements can greatly help the relevant engineer assess the extent of any corrosion problem that is present and determine the most beneficial corrective actions to take. Such actions may include a simple cleaning of connections and re-tightening of terminations, or coating terminations with anti-corrosion gels (NO-OX) or plastic covers to reduce contamination of terminals, or up to the deployment of sacrificial anodes in the manhole.

Groundwater and runoff from roads and fields that enter manholes can be contaminated with high levels of salts and electrolytes, which can also initiate corrosion in support and bonding hardware as well as network equipment in the manhole. Such circumstances may require may anti-

corrosion actions and possibly National Pollution Discharge Elimination System (NPDES) state permits for water discharge from manholes (see [Section 17.9](#)).

### 16.3 Normative and Informative References Related to Manholes

1. GR-902-CORE, *Generic Requirements for Handholes and Other Below-Ground Splice Vaults*.
2. Telcordia BSP Practice BSP-919-240-300, *Underground Conduit Manholes*.
3. Telcordia BSP Practice BSP-620-150-010, *Manhole Covers - Removing and Placing*.
4. Telcordia (Bellcore) Recommended Practice BR-877-302-100, *Corrosion Control of Grounding Electrodes at Remote Electronic Sites*.
5. Telcordia BSP Practice BSP-877-115-100, *Corrosion Practices, Application of Insulating Joints in Telephone Plant*.
6. GR-2836-CORE, *Generic Requirements for Assuring Corrosion Resistance of Telecommunication Equipment in the Outside Plant*.
7. ANSI/SCTE-77, *Specification for Underground Enclosure Integrity*.
8. ASTM C857, *Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures*.
9. ASTM C1037, *Standard Practice for Inspection of Underground Precast Concrete Utility Structures*.
10. ACI 318, *Building Code Requirements for Reinforced Concrete*, American Concrete Institute
11. ASCE Manual of Practice No. 118, *Below-ground Pipeline Networks for Utility Cables*.
12. ASTM C478, *Standard Specification for Precast Reinforced Concrete Manhole Sections*.
13. ASTM C497, *Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile*.
14. ASTM C858, *Standard Specification for Underground Precast Concrete Utility Structures*.
15. ASTM C891, *Standard Practice for Installation of Underground Precast Concrete Utility Structures*.
16. ASTM C923, *Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals*.
17. ASTM C990, *Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants*.

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# 17 Testing Manhole Atmosphere and Ventilating Manhole

## 17.1 General Precautions

**Note:** It is important that before opening a manhole, the communications company shall be contacted. See [Chapter 16, “General Precautions and Work Rules for Manholes.”](#)

The following safety precautions shall be taken before entering any manhole:

1. Manhole guards and warning devices shall be set up before entering a manhole.

**Note:** Never enter a manhole, even momentarily, until it has been tested for combustible gas and then power ventilated (purged) with the blower operating at a maximum rated speed for the times specified in this chapter. The blower must remain in operation the entire time anyone is in the manhole.

2. The blower shall not be operated in any type of enclosure such as a tent, vehicle, or trailer (unless designed for this operation), tool cart, etc. Locate the blower in an unconfined space with the blower intake away from the manhole opening. The blower should be located a minimum of 3 to 5 feet (0.9 to 1.5 m) from the manhole opening to avoid returning purged air into the manhole.
3. Whenever possible, position the blower air intake so it faces the prevailing wind direction, and is less subject to exhaust fumes from vehicular traffic. When the blower is powered by or used together with other portable generator units, direct the exhaust from these units away from the air intake of the blower unit.
4. ***Care should be taken when setting up the blower hose to prevent unnecessary bends or restrictions*** as they will reduce the air output at the end of the blower hose to below the certified rate. During purging (blower hose with one 90-degree bend), the hose end should extend into the manhole a minimum of 1 foot below the ceiling and should be at least 2 feet above the floor level.
5. Only communications company approved lighting and heating equipment and tools should be used. Connections to and disconnection from electric lighting, equipment, etc., should be made outside the manhole. Wet-cell storage batteries should not be brought into a manhole.

### 17.1.1 Tents

Where a tent is placed over a manhole opening before initial ventilation begins, the skirts of the tent should be rolled at least 1 foot above the ground to provide an open area around the bottom of the tent for adequate air circulation and for dissipation of possible gas accumulation. Opening the tent entrance flaps alone will not provide sufficient movement of air and may cause “pocketing of gases” inside the tent.

When a manhole shield is used, the tent skirts should be raised at least 1 foot above the top of the shield to provide an area for ventilation.

---

**! CAUTION !** *When a tent is in place during the purge, increase the purge time by 5 minutes.*

---

After purging, the tent skirts may be lowered, but the tent must be arranged to permit unrestricted air circulation from the tent.

---

**! CAUTION !** *The tent shall not be fully closed at any time.*

---

### 17.1.2 Open Flames and Furnaces

No open flame, torch, or other item that produces a hot spark shall be operated or ignited in a manhole unless specifically approved by company rules and procedures.

Any propane furnaces and other open flames shall be kept as far from an open manhole as practical and away from the blower air intake.

---

**! CAUTION !** *Under no circumstances shall a lighted cigar, cigarette, or pipe be brought near an open manhole, into a covering or tent over an open manhole, or taken into a manhole.*

---

### 17.1.3 Fusion Splicing Optical Fiber Cable in Cable Entrance Facilities (CEFs) and Manholes

Fusion devices differ from other spark-producing equipment or open flames in that the arc is under continuous control and observation by the operator, and there is no combustible material (polyethylene sheath, muslin, or pulp insulation) in the immediate area where the arc is produced.

Fusion splicing can be safely performed in manholes and CEFs if the following requirements are met:

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- Testing, purging, and power ventilating requirements are followed as described in this chapter.
- A suitable continuous gas monitor ([Section 17.2.2](#)) is used to detect combustible gases.
- The procedure is approved by the communications company work practices.

#### 17.1.4 Radon in Manholes

Radon is present in the soil and produced by the radioactive decay of uranium. Since radon is much heavier than air, it tends to be more concentrated in below-ground spaces where it enters via diffusion through cracks and crevices. Because of this characteristic, in areas where significant radon gas concentrations exist from geological conditions, the underground communications conduit and manhole systems represent natural pipelines and a potential collection point for radon.

Studies were conducted to determine the necessary procedures that would control potential radon exposure in communications manholes. These studies confirmed in all cases that the standard manhole purging and ventilating criteria described in this chapter, when followed, are effective in lowering concentrations of the radon contaminant significantly below OSHA limits and will provide a safe working environment.

**Note:** A series of tests in 1988 by R.A. Naser (Bell Communications Research) found that the procedures outlined in this chapter are effective at controlling any possible radon exposure in manholes. Laboratory and field tests were performed on cases with ambient random levels from 1-to-60 times the OSHA exposure limit, manholes ranging from 180-2300 ft<sup>3</sup> in volume, and using purge times between 5 and 34 minutes. In all cases where the purging protocols outlined here were followed, the exposure levels were lowered to a few percent (1-5%) or less of the prescribed OSHA limit.

### 17.2 Gas Indicators and Monitors

The hazardous gases most likely to be found in underground structures are those used for household fuel. However, gases generated in the soil, liquid fuels that occasionally escape into conduit and manholes, and oxygen deficiency can occur and can cause hazardous conditions.

Two types of gas indicators/monitors are available:

- Non-continuous gas indicators (hand-aspirated)
- Continuous gas monitors.

**Note:** With the meters and technologies currently available, the use of continuous gas monitor are routine tools now and the non-continuous indicators are mostly phased out.

***The manufacturer's instructions for testing, operation, calibration, and maintenance of the indicator/monitor should always be followed.***

Both types of indicators/monitors are capable of detecting single or multiple gases. However, most non-continuous gas indicators are single gas indicators that are calibrated to detect combustible gas only. Most continuous gas monitors have multiple sensors and can detect and measure concentrations of combustible gases, toxic gases (i.e., carbon monoxide and or hydrogen sulfide), and oxygen. Continuous gas monitors measure gas concentrations continuously and simultaneously.

---

**! CAUTION !** No matter what type of gas indicator/monitor is used, the requirements for **purging and continuous ventilation** covered in this section must be observed.

*The indication of a non-explosive manhole atmosphere does not eliminate the necessity of purging for the prescribed times and maintaining continuous ventilation during occupancy.*

---

In manholes where toxic gases are likely to occur, the purge times given in this document should be increased by 50%.

All users of gas indicators/monitors need to be aware that if a very heavy concentration of gas is present, the analog pointer or digital reading will move rapidly to the top of the scale and then return to some point or reading above zero, at zero, or below zero. If this up/down motion is not observed, the user may erroneously assume that the atmosphere being tested is safe when actually a very dangerous condition exists. This is the reason for stressing continuous observation of the indicator/monitor until the initial evaluation of the atmosphere is complete.

### 17.2.1 Non-Continuous Gas Indicators (Hand-Aspirated)

There are several types of non-continuous gas indicators with specific features and functions. This discussion is centered around the widely used hand-aspirated hot filament gas indicator that, when used according to the manufacturer's instructions, will indicate the percentage of the Lower Explosive Limit (LEL) of combustible gas present in the atmosphere being tested.

The general approach is that a reading showing a gas concentration above the 10% LEL indicates an unsafe atmosphere. An indicator reading showing a gas concentration below the 10% LEL indicates a non-explosive atmosphere.

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Most gas indicators and modified existing gas indicators have a meter scale with a green band denoting 0%–10% LEL, and a red band for combustible gas concentrations above 10–100% LEL. A reading of 100% LEL indicates a concentration of gas in the air that will explode or continue to burn when ignited.

Whichever detector is chosen, it is desirable that the display can provide clear readings in low light, bright light or anywhere in between. This feature helps provide safety information independent of if the work location is outside, inside or underground. A color display is preferable to more rapidly catch the attention of the worker. With new meters, any on-board graphing and data recording features of the direct readings will help in later analysis and investigations.

When using the gas indicator in any area, if the meter display or pointer moves to 100% or to the top of the scale and stops there, it indicates a hazardous gas concentration near or above the LEL. When this occurs, turn the instrument off and purge it with fresh air by removing the hose and squeezing the bulb about 5 times to prevent meter damage.

When using the gas indicator in any area, if the meter pointer moves rapidly to the top of the scale and then returns to some point on the scale, or to zero or below, it indicates a gas concentration above the LEL, possibly a very high concentration of gas. When this occurs, the instrument should be turned off immediately and purged with fresh air to prevent damage to the meter. Also, the instrument should be re-checked with the gas test kit, as the high gas concentration may have burned out the meter filament.

### 17.2.2 Continuous Gas Monitors

The continuous gas monitor is designed to continuously test the working atmosphere in the nearby area. It can provide an extra measure of security in a manhole that has a history of combustible gas occurrences.

Continuous gas monitors are available with one or more gas sensors to detect and measure concentrations of gases, e.g., combustible gases, oxygen, carbon monoxide, and/or hydrogen sulfide. Other types of sensors may be required for special situations.

The monitors have a variety of display and alarm features. Some models automatically indicate all gases being monitored and their levels simultaneously and continuously. On other models the display is activated by selecting a switch(es) for the type of gas being tested. All models, however, must monitor gas concentrations continuously and simultaneously.

***All continuous gas monitors must have combustible gas-detection sensors and may have, in addition, toxic gases and oxygen sensors.***

Combustible gases are measured and displayed in percentages of LEL, while oxygen is measured in percent by volume, and toxic gases in parts per million. Models must have audible and visual alarms that are factory set to warn the

user of the following conditions:

- When the percent of LEL of combustible gas exceeds 10%
- When the oxygen percentage falls below 19.5 or rises above 23.0
- When the Permissible Exposure Limit (PEL) as an 8-hour Time-Weighted Average (PEL 8-hr TWA) or the present Threshold Limit Value (TLV) exceeds 35 parts per million (ppm)

**Note:** Permissible Exposure Level (PEL) 8-hr Time-Weighted Average (TWA) is defined by OSHA in the Federal Register to mean “TWA is the employee’s average airborne exposure in any 8-hour work shift of a 40-hour work week which shall not be exceeded.” The 8-hour TWA PEL is the level of exposure established as the highest level of exposure an employee may be exposed to without incurring the risk of adverse health effects.

- When the PEL 8-hr TWA or the present TLV for hydrogen sulfide exceeds 10 ppm.

While the monitor is activated, the sensors are continuously sampling the atmosphere. Audible and visual alarms are provided for sensor failure or omission and for low battery conditions.

For any continuous gas monitor to be effective, an adequate supply of air sample must be available to the sensors. In diffusion units, the filter screen must be kept free of condensed moisture. Check the filter screen periodically and clean by shaking, blotting, or using forced air. Units with sampling pumps shall have a low-flow alarm to indicate reduced flow of the air sample. Both types of monitors shall have their filters cleaned and/or replaced as needed or as per the manufacturer’s recommendations and directions.

Indications that are either negative or greater than 100% LEL may signify an explosive concentration of combustible gas. These indications may also signify instrument malfunction. Any rapid upscale indication followed by a declining or erratic indication, or an indication greater than 100% LEL, may signify a gas concentration beyond the accurate response range of the sensor. An oxygen-deficient atmosphere will cause erroneous low determinations of the combustible gas content of the air. An oxygen-enriched atmosphere will cause erroneous high determinations of the combustible content in the air. Other combustible vapors may also cause erroneous readings.

## 17.3 Blowers

### 17.3.1 Blower Capacities

Manhole ventilation with forced air is necessary to expel unwanted gases that may be present in the manhole atmosphere and to maintain an adequate supply of oxygen. To determine initial ventilation (purge) times,

the effective blower capacity and manhole volume must be known.

The effective capacity is defined as the actual ventilation system air output in Cubic Feet per Minute (CFM) delivered at the end of the blower hose.

The ventilation system may consist of only a blower and blower hose, or may include a heater and other components. Effective blower capacity, as stated by the blower manufacturer in the catalog, specifications, or on the nameplate of the blower, are expected to be determined by precision airflow chamber tests performed by independent testing laboratories on the ventilation system, including all the components that are part of the system.

***Substitute components that differ from the original item can alter the effective capacity.***

The performance tests are made with one 90-degree bend (purging position) in the blower hose and with two 90-degree bends (continuous ventilation position) in the blower hose, and the results are certified by the testing laboratory. This information should be permanently and conspicuously mounted on the blower and incorporated into the product specification(s).

### 17.3.2 Blower Maintenance

All blower units need to be cleaned and checked periodically to be sure they are operating at rated speed. Slower than rated blower speed will cause a reduction in air delivery.

**Note:** The frequency of preventive maintenance and operational checks will be specified by the manufacturer but should never exceed 1 year.

Recertification of the blower capacity should be performed if substitute components are used, or after extensive maintenance or repair work.

Air delivery of electrically powered blowers generally will not vary from the norm if line voltage and frequency are held at the value that the motor is designed for and there is no damage to the blower components.

Air delivery of blowers powered by internal combustion engines will vary appreciably if the engine is not properly maintained and adjusted to operate at the governed engine speed as specified by the manufacturer.

***Blower hoses shall be in good condition.*** Hoses with leaks, tears, or other damage can cause a marked reduction in air delivery and, therefore, must be replaced as required. The replaced hose shall have the same internal configuration (smoothness), or better, as the original hose. A blower hose with a high coefficient of friction (rough internal surface) can reduce blower delivery by up to 50%.

## 17.4 Setups for Testing and Purging Manholes

### 17.4.1 General

Initially test for combustible gas with the end of the sampling tube at about the head height for a person working in a normal position in the manhole.

If this cannot be accomplished by lowering the tube directly into the manhole, a permanent installation of gas sampling tubing extending into the manhole should be provided. The tubing should be installed with one end at or near the middle of one sidewall and at about head height away from the direct output of the blower. The other end should terminate in the manhole entrance and be accessible from a position outside the manhole collar. The end in the manhole entrance should be equipped with a capped end fitting for attaching the gas indicator/monitor hose, and a valve for connecting an air chuck to clear the tubing of any residual gas, dirt, or water.

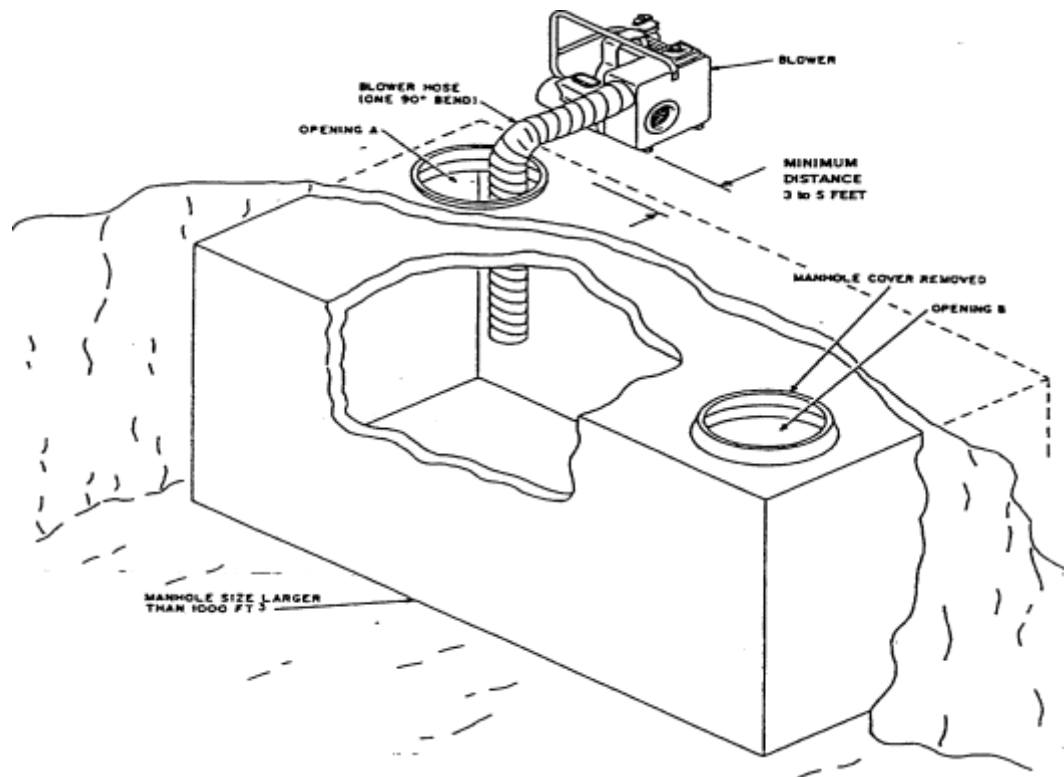
Run the blower to clear the blower hose of any contaminant before placing the hose in the manhole.

### 17.4.2 Conventional Manholes

Conventional manholes are rectangular in shape with access through the manhole roof and with the collar height short enough so the standard blower hose is adequate in length for purging and for continuous ventilation.

Manholes that are smaller than 1000 cubic feet are purged by opening one manhole cover and dropping the end of the blower hose into the manhole (one 90-degree bend in the blower hose). Conventional manholes larger than 1000 cubic feet are purged with two manhole covers removed at opposite ends of the manhole. The purge times are specified in [Figure 17-8](#) and [Figure 17-9](#). A typical setup is shown in [Figure 17-1](#).



**Figure 17-1 Typical Setup for Purging Large Conventional Manholes**

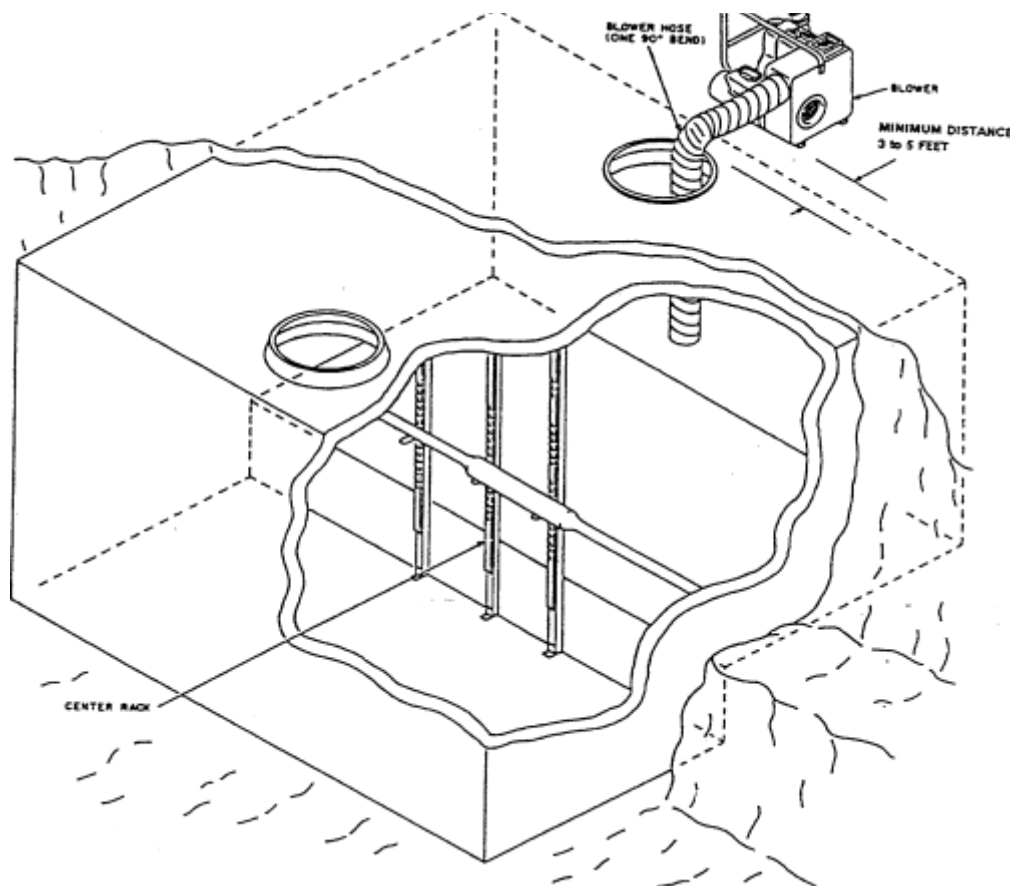
**Note:** Using two blowers, one in opening A and one in opening B, will reduce the purge time.

### 17.4.3 Irregular-Shaped Manholes

Irregular-shaped manholes often result from enlarging an existing conventional manhole. A typical example is shown in [Figure 17-2](#).

If the manhole has two floor levels, or if it is congested so that airflow is restricted, purge time should be based on the effective blower capacity with two 90-degree bends in the hose. Purge by positioning the blower hose into the manhole (one 90-degree bend in the blower hose).

**Figure 17-2 Typical Setup for Purging Irregular-Shape Manholes**



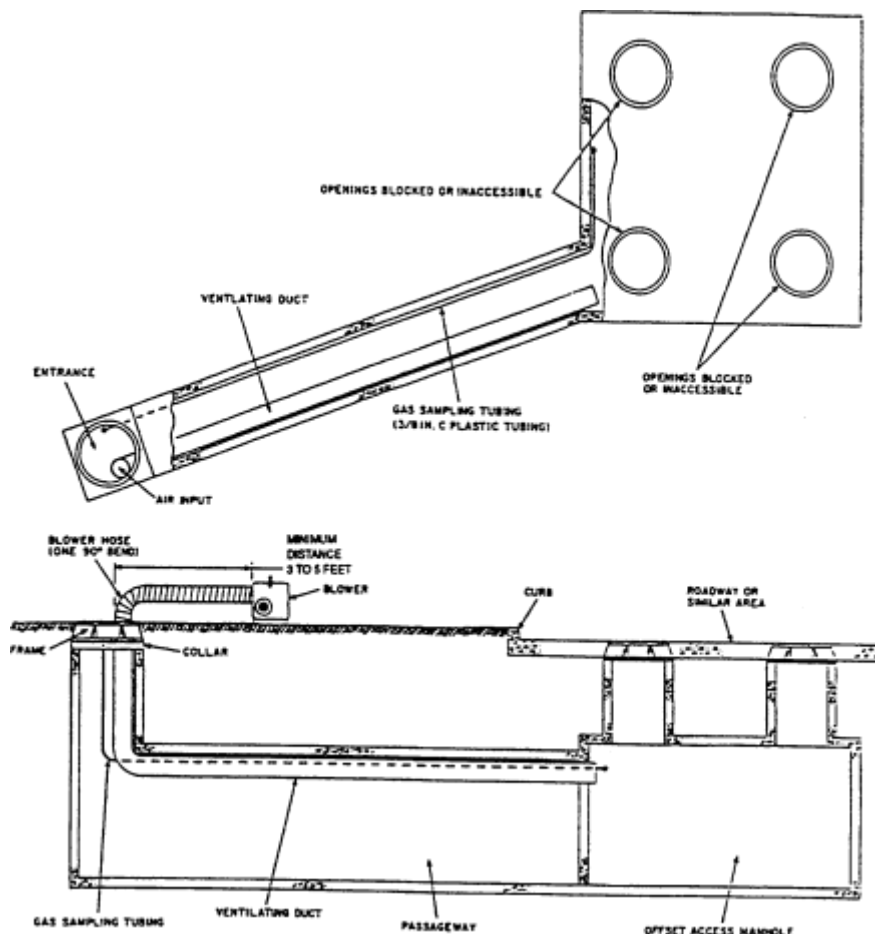
**Note:** Base purge time on effective blower capacity with two 90-degree bends in the blower hose.

### 17.4.4 Offset-Access Manholes

Offset-access manholes are those manholes that require entry through either an access opening several feet from the manhole, or an adjacent manhole and a connecting horizontal passageway. Adequate purging and ventilation for these manholes can be achieved only through permanently installed ventilation – ducts that will introduce air directly into the offset-access manhole. Examples of ventilating duct locations are shown in [Figure 17-3](#) and [Figure 17-4](#).

Purging and ventilation of offset-access manholes are accomplished by inserting the end of the blower hose into the upper end of the permanently installed ventilating duct. When inserting the blower hose, its end should be several inches above any 90-degree bend in the duct so airflow will not be impeded.

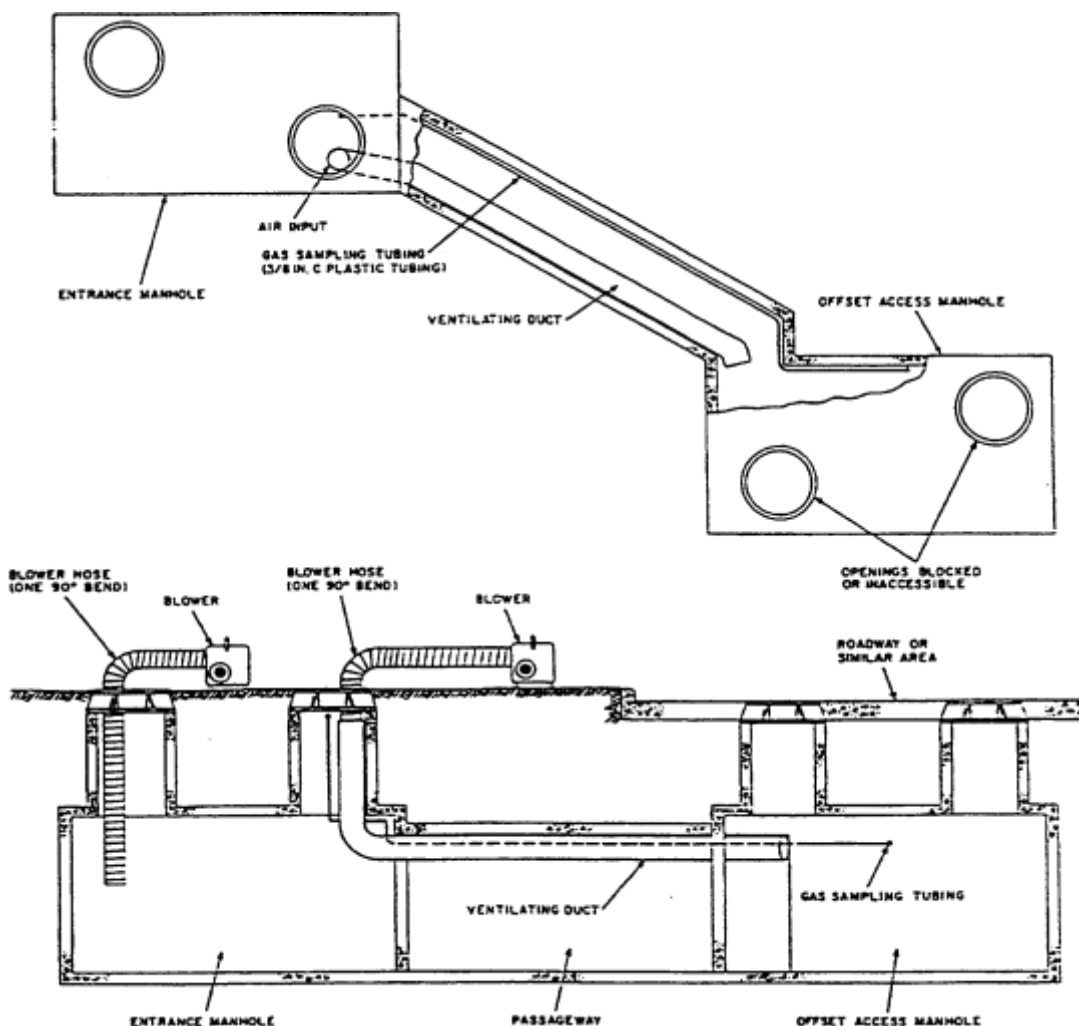
**Figure 17-3 Typical Setup for Purging Offset-Access Manhole with No Entrance Manhole**



**Note:** Base purge time on effective blower capacity with one 90-degree bend in the blower hose.

Purge times for offset-access manholes are determined using the effective blower capacity with one 90-degree bend in the blower hose and the sum of the volumes of the manhole and the passageway. When entry into the offset-access manhole is through an adjacent manhole and a passageway, both the entrance manhole and the offset-access manhole must be ventilated anytime work is done in either one or both of the manholes. Each manhole is ventilated independently (two blowers, hoses, gas tests, etc.); however, purge time for each manhole will be the same and will be the purge time determined for the larger of the two manholes. The volume of the passageway added to the volume of the offset-access manhole is considered as the total volume of the offset-access manholes.

**Figure 17-4 Typical Setup for Purging Offset-Access Manhole with Entrance Manhole**



**Note:** Two blowers must be used: one for the entrance manhole, and one for the offset access manhole.

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### 17.4.5 Deep-Neck Manholes

For the purpose of this section, deep-neck manholes are defined as those manholes requiring entry through the roof and that have a long collar height so that one 15-foot blower hose is not adequate in length for purging and for continuous ventilation.

Deep-neck manholes may be purged and ventilated by:

- Coupling two standard blower hoses together ([Figure 17-5](#)), or
- Through a permanent ventilating duct system, as per [Figure 17-6](#), and similar to the arrangement used for offset-access manholes ([Section 17.4.4](#)), or
- Through a separate permanent ventilating duct installed adjacent to the manhole and shown in [Figure 17-7](#).

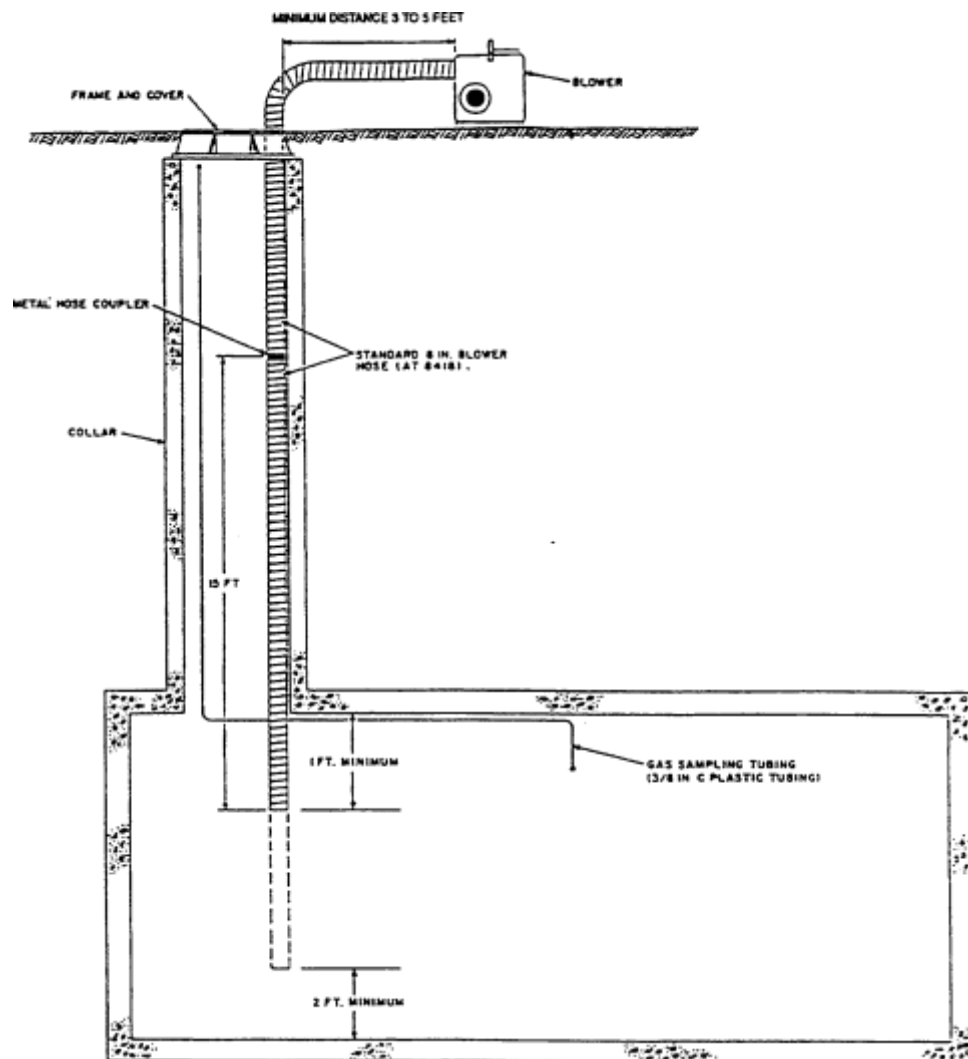
If the collar height is greater than 5 feet, the volume of the collar must be added to the volume of the manhole for determining purge times.

When purging with the coupled hoses, purge time should be based on the effective blower capacity with two 90-degree bends in the standard blower hose to compensate for the pressure drop in the longer hose.

Where a permanent ventilating duct is installed, the effective blower capacity with one 90-degree bend in the blower hose should be used to determine purge time.

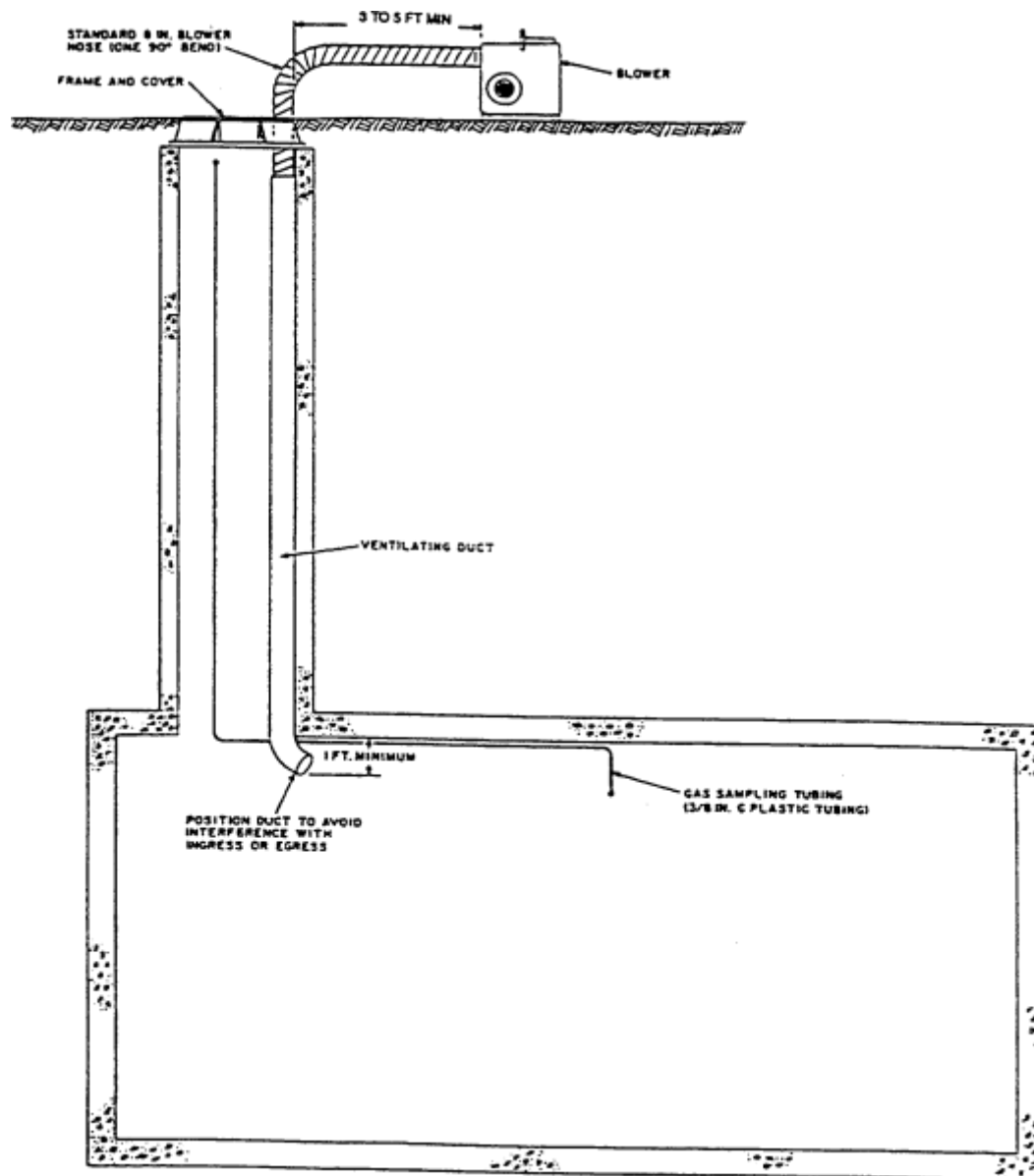
Ventilating ducts should be placed to avoid interference with winch lines suction hoses used for pumping water or other fluids out of the manhole. In addition, any ventilating duct shall be configured to direct the airflow either diagonally across the manhole or along a long dimension of the manhole. A cap or cover should be provided for the upper end of the ventilating duct when it is not in use. Ventilate by inserting the blower hose at least 12 inches into the ventilating duct(s).

**Figure 17-5 Deep-Neck Manhole Ventilated by Coupling Two Blower Hoses**



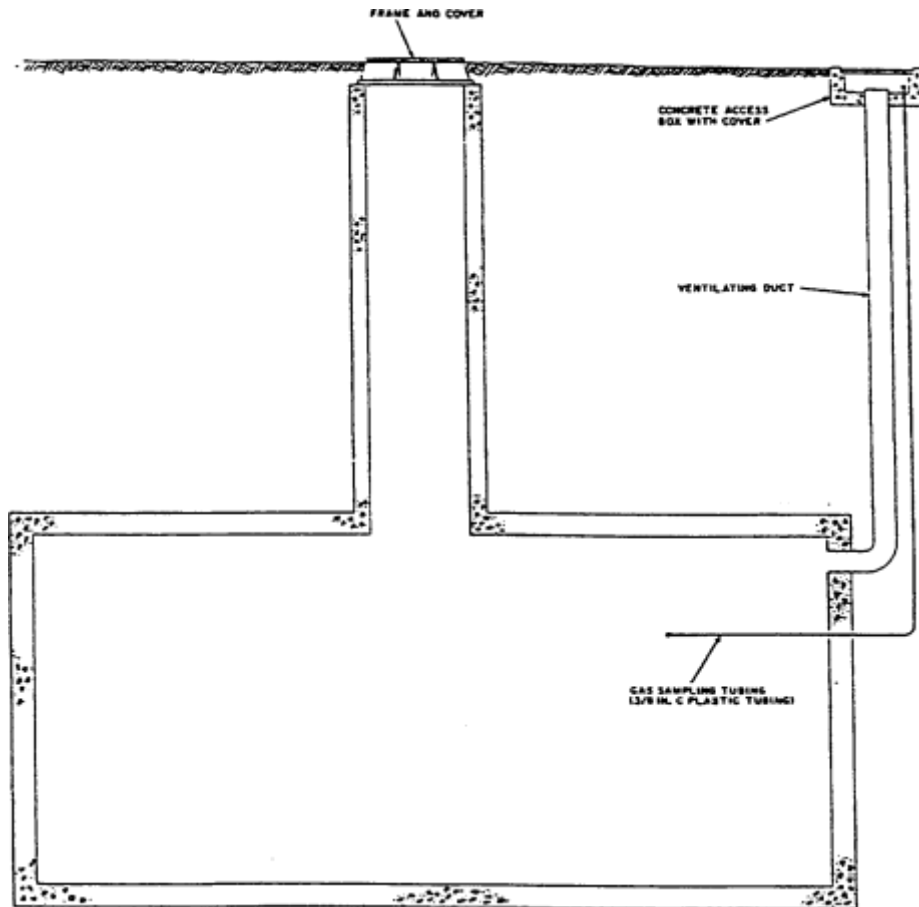
**Note:** Base purge time on effective blower capacity with two 90-degree bends in the blower hose.

**Figure 17-6 Deep-Neck Manhole Ventilated with Permanent Ventilating Duct Installed in Collar**



**Note:** Base purge time on effective blower capacity with one 90-degree bend in the blower hose.

**Figure 17-7 Deep-Neck Manhole Ventilated with Permanent Ventilating Duct Adjacent to Manhole**



- Note:** [1] Ventilating duct may enter through manhole roof.  
 [2] Base purge time on effective blower capacity with one 90-degree bend in the blower hose.

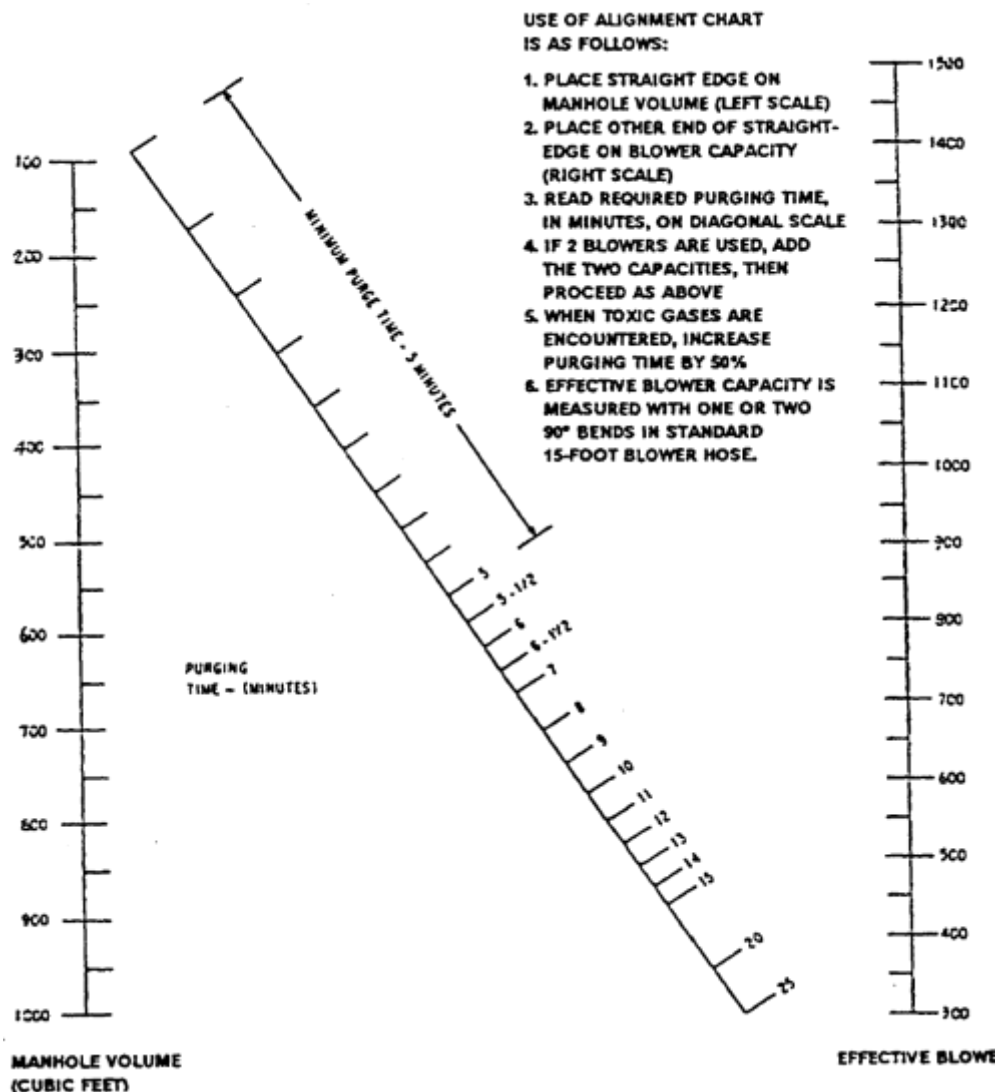
## 17.5 Purge Times

The minimum purge time for any ventilation activity is 5 minutes.

### 17.5.1 Alignment Charts

Purge times specified in the alignment charts ([Figure 17-8](#) and [Figure 17-9](#)) are based on 10% LEL for a combustible gas. When toxic gases are presumed to be present or are detected by odor in the manhole, the purge time determined by using the alignment charts should be increased by 50%. Report the condition to the supervisor.



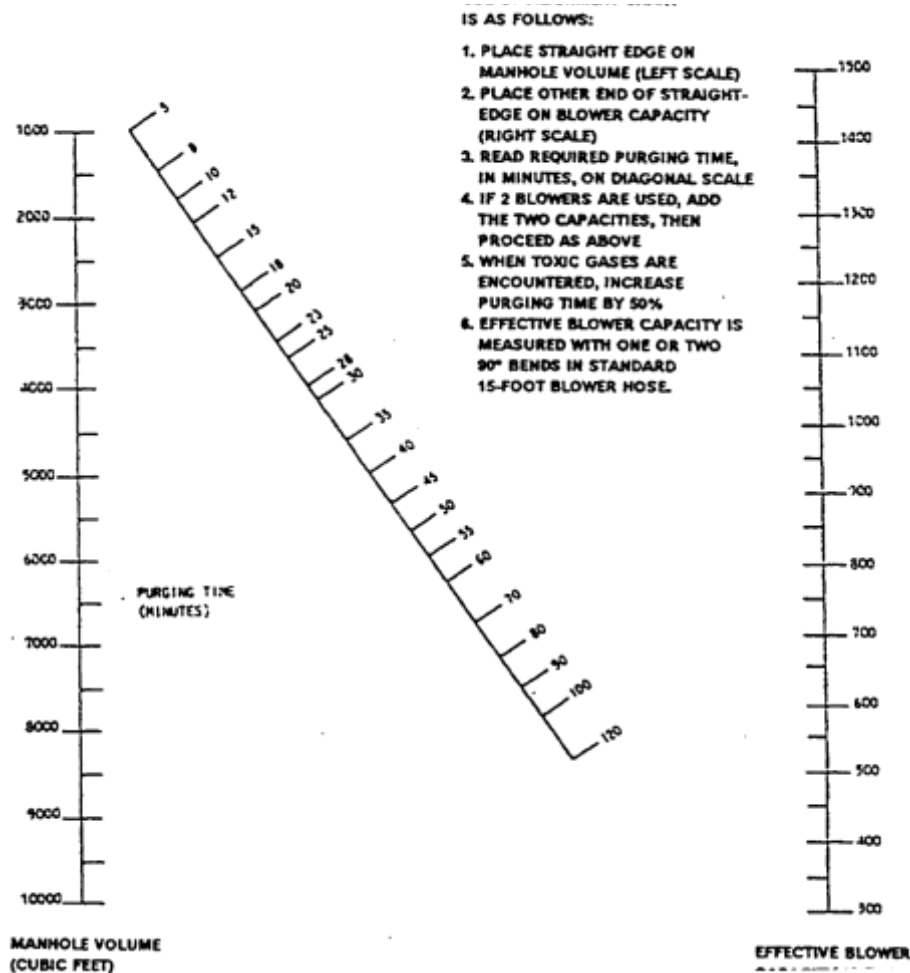
**Figure 17-8 Alignment Chart – Side 1 Covering Small Manholes**

| Effective Blower Capacity (CFM) With | Conventional Manhole (to 1,000 ft <sup>3</sup> ) | Offset-Access Manhole (With Permanent Ventilating Duct) | Deep-Neck Manhole          |                | Irregular-Shaped Manhole |           |
|--------------------------------------|--------------------------------------------------|---------------------------------------------------------|----------------------------|----------------|--------------------------|-----------|
|                                      |                                                  |                                                         | Permanent Ventilating Duct | Coupled Hose   | Uncongested              | Congested |
| One 90-deg bend                      | X                                                | X                                                       | X                          |                | X                        |           |
| Two 90-deg bends                     |                                                  |                                                         |                            | X <sup>a</sup> |                          | X         |

a. Use blower capacity with two 90-degree bends, unless the blower has been certified with a coupled hose having one 90-degree bend.

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**Figure 17-9 Alignment Chart – Side 2 Covering Larger Manholes**

| Effective Blower Capacity (CFM) With | Conventional Manhole (to 10,000 ft <sup>3</sup> ) | Offset-Access Manhole (With Permanent Ventilating Duct) | Deep-Neck Manhole          |                | Irregular-Shaped Manhole |           |
|--------------------------------------|---------------------------------------------------|---------------------------------------------------------|----------------------------|----------------|--------------------------|-----------|
|                                      |                                                   |                                                         | Permanent Ventilating Duct | Coupled Hose   | Uncongested              | Congested |
| One 90-deg bend                      | X                                                 | X                                                       | X                          |                | X                        |           |
| Two 90-deg bends                     |                                                   |                                                         |                            | X <sup>a</sup> |                          | X         |

a. Use blower capacity with two 90-degree bends, unless the blower has been certified with a coupled hose having one 90-degree bend.

Accurate purge times can be determined from the alignment charts if effective blower capacity and manhole volume are known. For large manholes, purge times may be reduced by using two blowers if the manhole has two access openings. When using two blowers, the sum of the blower capacities is used as the effective blower capacity on the alignment chart. Only one blower hose may be placed in any manhole access opening if the opening is to be used for entry and exit.

Each manhole with a volume greater than 500 cubic feet, or other volume designated by the communications company as the cut-off size, should have its volume in cubic feet permanently marked and clearly visible without having to enter the manhole in accordance with approved communications company practices. For example, the volume may be recorded on a permanent plastic or metal tag that is secured in the manhole collar on a patch of high-visibility paint.

The purge times for all manholes of a size equal to or smaller than the 500 cubic foot cut-off size are as follows:

- 10 minutes with a 400 CFM blower
- 8 minutes with a 500 CFM blower
- 5 minutes with a 800 CFM blower.

If a different cut-off size is adopted or blower capacities differ, purge times must be established from the alignment charts.

***Minimum purge time shall be 5 minutes.***

## 17.5.2 Determining Purge Times

To determine purge times for a manhole that has not been tagged, or has the tag missing as indicated by a paint patch but no tag, obtain the manhole volume from work prints or other records.

If the manhole volume is not recorded, estimate the volume. When the purge time will be based on estimated manhole volume, **double the purge time** indicated on the alignment chart to compensate for possible errors in the estimate. After testing, purging, and ventilating, measure the manhole, apply the patch of high-visibility paint, and install a tag on which the manhole volume has been recorded. Notify the person responsible for maintaining records of manhole sizes so the volume of the manhole will be recorded.

Continuous ventilation is required after purging to ensure a safe working atmosphere. A blower operating with an effective blower capacity of no less than 345 CFM at the end of the blower hose with two 90-degree bends will maintain a safe working atmosphere in manholes of the sizes and configurations covered in this section, provided no additional contaminants enter the manhole, and air from the blower is introduced directly into the manhole via the blower hose or permanent ventilating ducts.

## 17.6 Testing, Purging, and Ventilating Manholes

This section, coupled with [Figure 17-10](#) and [Figure 17-11](#), provides a summary of the manhole testing, purging, and ventilating procedures. Read the complete section thoroughly to ensure the procedures are understood.

### 17.6.1 General

The individual testing for gas should be set up (located) in a position that will cause minimum interference with either vehicular or pedestrian traffic. The work should be planned so that a minimum amount of time is spent in traffic areas.

Every manhole opened after having been closed for any period of time should be tested for the presence of combustible gas. The initial test(s) should be made immediately after the manhole cover is removed and before the manhole is purged.

Manufacturers' instructions shall be followed to test the indicator/monitor. The gas indicator/monitor shall be tested for proper operation each day before the first manhole test is made at each change of work shift if dropped or if exposed to a high concentration of gas. Never test the operation of a gas indicator/monitor by sampling fumes from a tank or engine exhaust or can containing gasoline because the high concentration of gas could damage the instrument.

**Note:** Daily verification of the operation and calibration checks for the gas detectors are desirable procedures since these units are used to detect the presence and concentration of toxic and combustible gases, as well as oxygen deficiency or oxygen enrichment. The responsiveness of sensors will vary with workplace environmental conditions, such as temperature and humidity. Therefore, to whatever degree practical, operators should calibrate sensors in conditions that are similar to workplace conditions. A calibration check with a test gas as the reference point is good practice, and checks should be performed daily (or prior to use) to avoid using a meter degraded by exposure to high concentrations of the target gases, vapors or particulates, or by the effects of accidental vibration or physical shocks on electronic components and circuitry.

### 17.6.2 Initial Test Prior to Entry

The initial test shall be made as follows:

1. Hold the instrument securely, or place it on a firm support during the test to prevent the instrument from falling.
2. Position the hose or sensor at the height where a person's head will be when working in the manhole (see Note). Additional lengths of hose may be used to test the lower portions of deep manholes, or permanently installed gas sampling tubing can be provided. If water in the manhole is above head height, hold the sampling hose 1 foot above the water.

**Note:** Use permanently installed sampling tubing in offset-access manholes.

Any water in the manholes equipped with permanently installed gas sampling tubing must be pumped out to a level at least 1 foot below the end of the tubing. Blow air through the tubing to clear it of water.

3. Draw a sample of the manhole atmosphere through the gas indicator/monitor. ***The indicator/monitor must be observed continuously until the test is completed.*** Keep aspirating or pumping until the highest reading is obtained.

**! CAUTION !** All users of gas indicators/monitors need to be warned and made aware that if a very heavy concentration of gas is present, the analog pointer or digital reading will move rapidly to the top of the scale and then return to some point or reading above zero, at zero, or below zero. If this up/down motion is not seen, this could lead to the erroneous assumption that the atmosphere being tested is safe when actually a very dangerous condition exists. This is the reason for stressing **continuous observation of the indicator/ monitor until the test is complete.**

**Note:** The removal of water from a manhole may permit gas to flow from the ducts into the manhole; therefore, after purging the water, but before entering the manhole, an additional gas test shall be made after the manhole has been pumped or a minimum water level has been reached with continuous pumping. The blower must be in continuous operation while anyone is in the manhole.

***If the initial test indicated a satisfactory atmosphere,*** purge the manhole for the appropriate time specified on the alignment chart or as tagged. The manhole may be entered after purging has been completed.

***If the initial test indicated an unsatisfactory atmosphere,*** make a second test after the blower has operated for the specified purge time. Make the test with the sampling hose or sensor away from the direct output of the blower.

- If this test indicates an unsatisfactory atmosphere, operate the blower for an additional 10 minutes and repeat the test.

- If any gas is detected at this time, do not enter the manhole. Report the condition to the supervisor.
- If the manhole atmosphere is satisfactory, the manhole may be entered. The blower must be in continuous operation while anyone is in the manhole.

**Note:** Before entering a deep-neck or an offset-access manhole, or any manhole equipped with gas sampling tubing, test the atmosphere in the collar area just below the manhole cover location. Make this test with the blower(s) operating. This test is required in addition to the test of the manhole atmosphere, even though the manhole atmosphere tests clear.

### 17.6.3 Tests at Entry

After purging has been completed, do the following:

1. Enter the manhole with the gas indicator/monitor, remote sensor, or remote sampling probe and, where possible, place the blower hose in a horizontal position along a side wall approximately midway between the floor (or platform) and the manhole roof.

***The blower must remain in operation the entire time anyone is in the manhole.***

2. Direct the blower hose outlet toward an end wall, preferably away from the work area.
3. Perform the gas test by probing in the area of all duct entrances, in corners, crevices, etc., and then generally throughout the manhole.
4. For offset-access manholes, on entry into the entrance manhole, test for gas at the duct entrances, in the corners, in the passageway, and at the duct entrances, and in the corners of the offset-access manhole.

**Note:** To purge the gas indicator/monitor, remote sensor, or remote sampling probe while in the manhole, detach the sampling hose and hold the gas indicator/monitor, remote sensor, or remote sampling probe in the fresh air near the end of the blower hose or ventilating duct.

If the tests in the manhole are satisfactory, proceed with the work operation. If gas is detected, leave the manhole immediately. Purge the manhole for an additional 10 minutes. Re-test the manhole atmosphere from street level. If gas is detected, do not enter the manhole. Notify the supervisor. If the atmosphere is clear, re-enter the manhole and repeat the tests in the manhole. If gas is detected after re-entering, leave the manhole immediately and notify the supervisor. If the atmosphere is clear, proceed with the work operation.

### 17.6.4 Tests and Precautions During Work Operations

After the work in any manhole has begun, additional tests must be made as follows to help assure that the worker remains safe and alert to changes within the atmosphere of this confined space:

1. **If duct plugs are removed**, immediately test for combustible gas at the ducts that were opened.
  - If gas is detected, leave the manhole immediately.
  - Purge the manhole for 10 minutes and retest the manhole from street level.
    - If gas is still being detected, do not enter the manhole, and notify the supervisor.
    - If the atmosphere is clear, re-enter the manhole and repeat the tests:
      - If gas is detected, leave the manhole immediately and notify the supervisor.
      - If the atmosphere is clear, continue the work operation.
2. **When each crew begins work, repeat tests** at ducts and throughout the manhole. (Follow the procedures in the previous paragraph.)
  - If gas is detected, leave the manhole immediately.
  - Report the condition to the supervisor.
3. **Test for gas** at intervals of not more than 2 hours, or every hour if gas was detected initially (shorten intervals to one half these times if a tent is being used). Repeat tests at ducts and throughout the manhole.
  - If gas is detected, leave the manhole immediately.
  - Report the condition to the supervisor.
4. **If the blower should stop, leave the manhole at once.**
  - Remove the blower hose from the manhole. The blower hose shall be kept out of the manhole while the blower is not operating.
  - When the blower is operating again, purge the hose. While purging the hose, test the manhole atmosphere.
    - If it is satisfactory, replace the blower hose, purge, and re-enter the manhole.
    - If the test is not satisfactory, purge the manhole and re-test the manhole atmosphere from street level.
    - If this re-test indicates an unsatisfactory atmosphere, operate the blower for an additional 10 minutes:
      - If the atmosphere tests clear, re-enter the manhole and repeat the tests in the manhole.

- If gas is detected, leave the manhole at once and notify the supervisor.
- If the atmosphere tests clear, continue the work operation.

Figures 17-10 through Figure 17-13 on the next 3 pages are summaries and decision trees providing summaries of the manhole testing, purging, and ventilating procedures. They should be read thoroughly to be certain the procedures are understood as well as followed in sequence with no boxes skipped over.



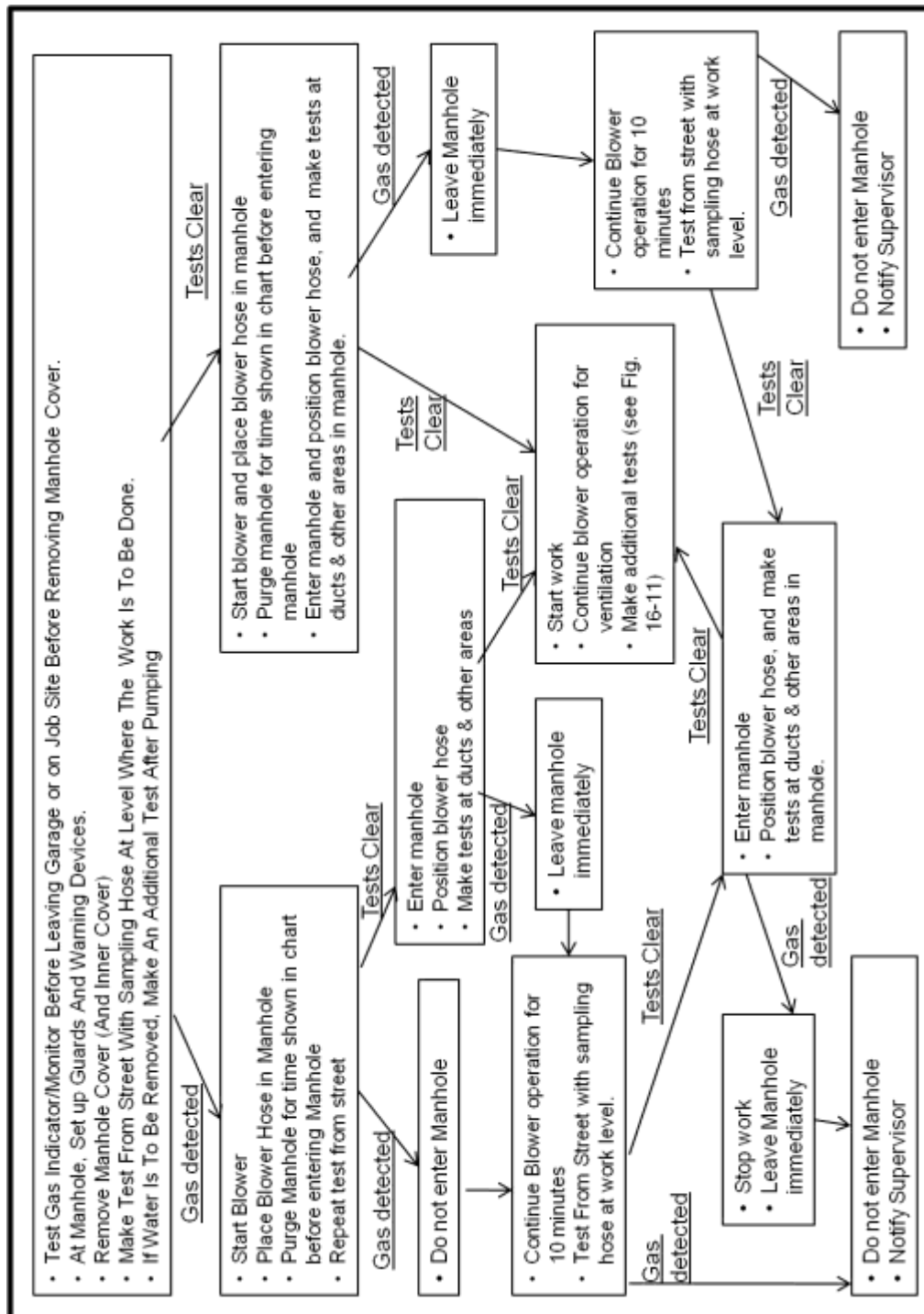
**Figure 17-10 Manhole Testing, Purging, and Ventilating Procedures – Initial Tests**

**Figure 17-11 Manhole Testing, Purging, and Ventilating Procedures – Additional Tests**

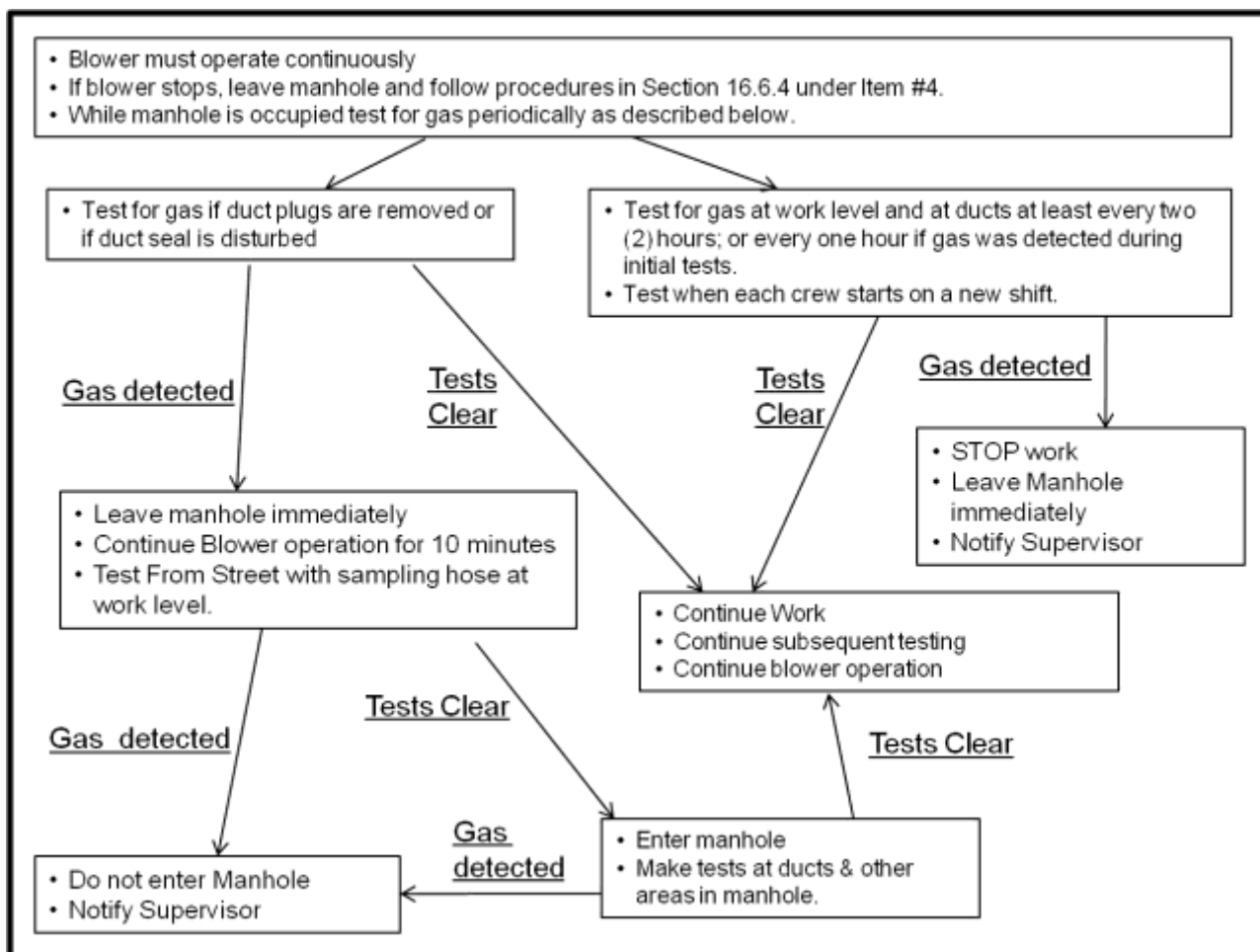


Figure 17-12 Decision Trees if No Gas Detected

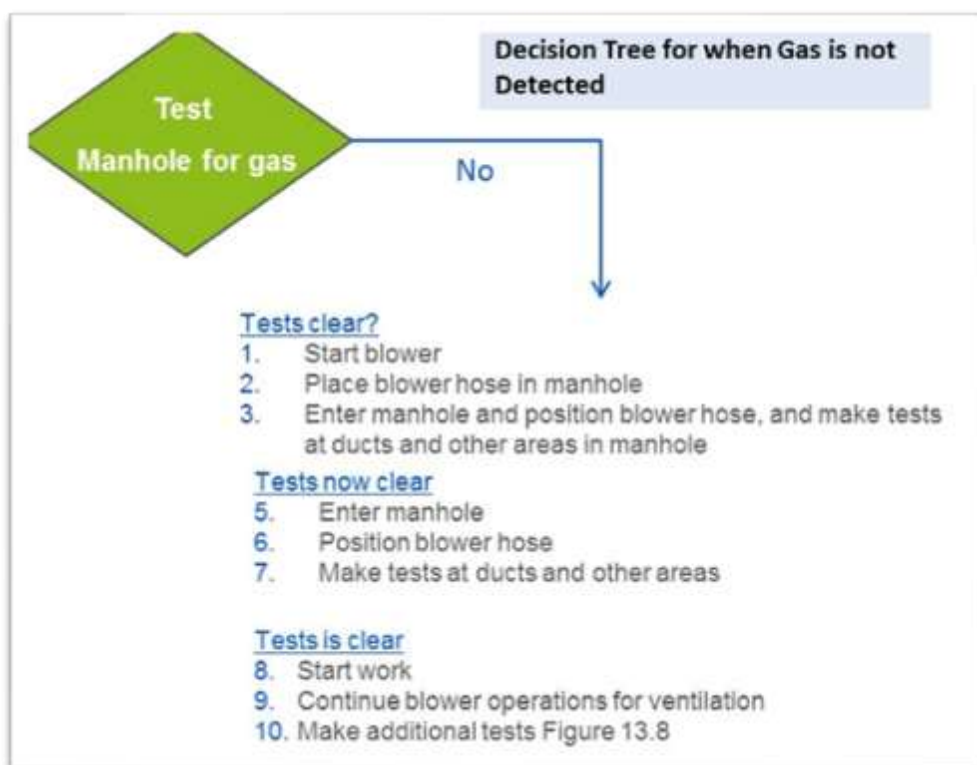
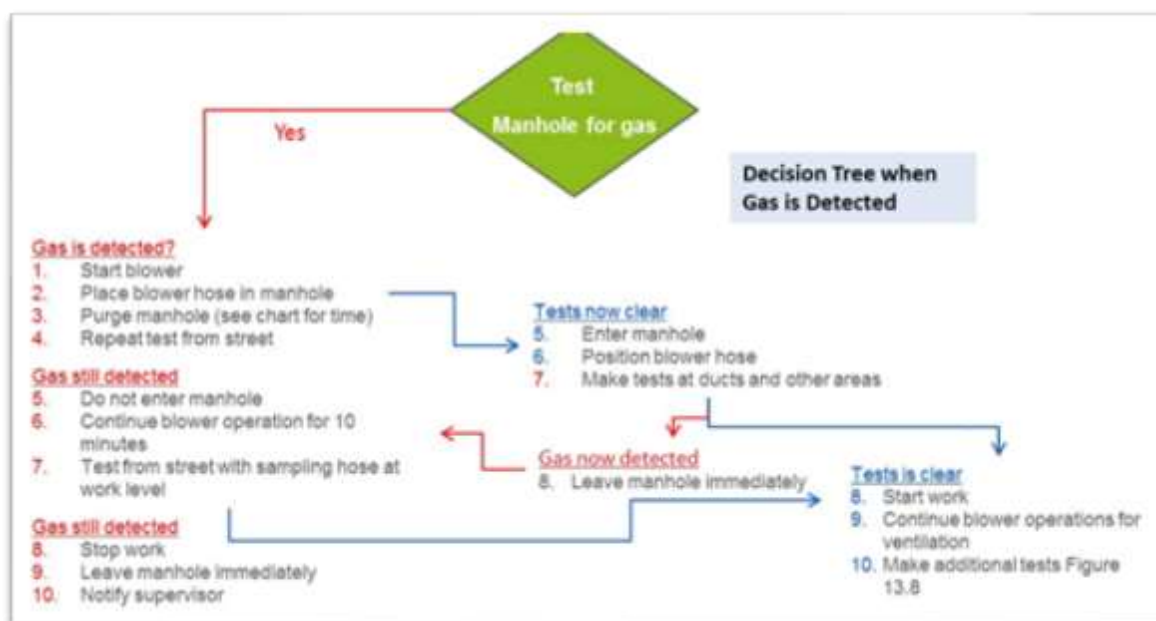


Figure 17-13 Decision Trees if Gas Detected



## 17.7 Testing Cable Entrance Facilities (CEFs) for Combustible Gas

### 17.7.1 General

The CEF is the interface or demarcation point between the Central Office (CO) facilities and the Outside Plant (OSP) network. The CEF provides space for the entrance and routing of various cables. The three main types of CEFs are: above surface, subsurface, and duplex.

The CEFs may be *enclosed* by walls, partitions, etc., to separate this space from adjacent building space, or *unenclosed* and thus be part of the same environment as the adjacent CO building. In general, CEFs fall into two categories: unvented and vented.

- An unvented CEF is normally an *enclosed* space, such as a cable vault, in which the only openings are access openings. Unvented CEFs must be tested for combustible gas prior to entry.
- A vented CEF is an *enclosed or unenclosed* area in which ventilation is provided by one of the following methods:
  - **Forced ventilation** – Provides air changes using a mechanical ventilation system to supply air under positive pressure. Combustible gas testing is generally not required prior to entry.
  - **Natural ventilation** – Provides air changes using exhaust flue stack(s) and low-level intake(s) operating on differentials of pressure and temperature for airflow. Combustible gas testing is always required prior to entry because air is not positively forced into the space.

Where a gas-venting chamber exists, the chamber should be tested for the presence of combustible gases and purged, if necessary, prior to removal of the conduit termination plugs in the CEF. Also, if a history of gas exists, always test the CEF for combustible gas prior to entry. In this situation, the installation of a permanent continuous gas monitor should be seriously considered.

### 17.7.2 Test Procedures

In the absence of specific communications company practices, CEFs shall be tested for gas in accordance with the procedures in the following paragraphs.

In some buildings, tubes or pipes have been placed between the CEF and some location outside the facility to facilitate testing. When such tubes or pipes have been placed, specific instructions indicating the number of tubes and the location where the tests can be made should be posted on or adjacent to the CEF entrance. It is recommended that the length of each tube be indicated at the various test points. These tubes or pipes should be considered as an extension of the sampling hose and should be aspirated or pumped accordingly when making tests.

If no tubes, pipes, etc., are provided to facilitate testing, open the CEF door just enough to position the sensor or hose intake in order to perform gas testing at multiple levels in the CEF and perform the tests.

If gas is detected during the tests, do not enter the area. Withdraw the indicator/ monitor, close the door, and notify the supervisor. If no gas is found, enter the CEF and test for gas in the area of the conduit entrance and generally throughout the CEF. If gas is found in the CEF, leave immediately, close the door, and immediately inform the supervisor and the person in charge of the building.

When gas is found, the supervisor must arrange for ventilation and any other steps necessary to prevent ignition of the gas. Care should be exercised to ensure that the ventilation method does not force gas from the CEF into other parts of the building.

After each operation involving disturbance of the existing duct plugs or duct seals in the CO manhole and/or CEF, the ducts should be re-sealed to minimize the possibility of gas entering through these ducts.

Under no circumstances shall lighted smoking materials or open flames be brought into the CEF. See [Section 27.2.3](#) for guidance on using fusion splicers for optical cables in CEF locations.

### **17.7.3 Testing Unattended Buildings for Combustible Gas**

When entering an unattended building having an underground cable entrance, the area above and around the cable ducts entering the building should be tested with the gas indicator/monitor. If gas is detected, ventilate the area by opening windows and doors. Notify the supervisor in accordance with local routine. This procedure may be omitted if posted or otherwise covered by communications company instructions.

### **17.7.4 Water Discharge from Manhole**

Throughout this section, it is assumed that a manhole that has a significant level of water shall be pumped before any ventilation or air testing is begun. Water and sediment inside a manhole could contain contaminations from surface and stormwater run-off, seepage from broken sewage or fuel lines, and other possible sources. Regulations based on the National Pollution Discharge Elimination System (NPDES) program are designed to prohibit discharging of contaminated water or sediment into the national waterways and watersheds.

There may also be local, state, county, or municipal requirements for managing water and sediment from an underground vault or manhole. It is advisable to know the local requirements in your area before de-watering or removing sediment from an underground vault or manhole.

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Accommodations can be made in individual state plans for the routine pumping of water from utility manholes to drains after a visual inspection of a water sample to evaluate contamination and turbidity levels or measurements of particulates present through testing of water.

Water in manholes can become contaminated with high levels of salts and electrolytes, which can initiate corrosion in support and bonding hardware inside the manhole. Evidence of contaminated water or excessive corrosion in wet manholes should be reported to a supervisor for further investigation.

## 18 Bonding Cables in Manholes and Handholes

### 18.1 General

This chapter covers the bonding together of cables in communications company manholes and handholes.

The purpose of bonding between cables is to reduce the overall impedance (and resistance) to ground and to equalize the potentials that may otherwise appear between cables. The equalization of the potential between cables protects the craftsperson by reducing the possibility of shock hazards and minimizes the possibility of damage to communications plant.

The reader shall refer to [Chapter 25](#) (see [Section 25.2](#) in particular) and [Chapter 10](#) ([Section 10.1](#)) for a fuller discussion of the purpose of bonding and grounding in communications network facilities.

Local conditions may require special measures other than those specified in the general bonding rules covered in this chapter. Information on these local conditions, and steps to be taken, will be conveyed by the local communications or telephone company.

**Note:** It is important to consider special protection measures in known corrosive areas. Measures must be in place to help ensure that consequences of any construction actions **do not** circumvent any corrosion mitigation measures placed by the communications company. Such corrosion areas should be identified by the local communications company.

Good bonding practices help reduce galvanic and electrolytic corrosion to cable shields, cable frames, rebar structures, equipment enclosures, and associated hardware by draining away undesirable voltages and currents. The elimination of such foreign and induced voltages/currents can also reduce noise in communications circuits and thereby improve service quality.

### 18.2 Location of Bonds

Cables used in the underground conduit system have either an outer metallic sheath or a plastic sheath. ***These cables shall be bonded at locations recommended by the communications company.*** Generally, cables with an outer metallic sheath shall be bonded at each manhole. Cables with an outer plastic sheath shall be bonded at manholes where a splice is made.

It is not necessary to bond cables with an outer plastic sheath where the cable has been pulled through the manhole and a splice has not been made. There is no need to open a cable jacket for the sole purpose of bonding or grounding the metallic shield of the cable.

### 18.3 Placing Bonds

Cables and equipment in manholes are usually bonded together with a tinned copper bonding ribbon that is 3/8 inch wide and approximately 1/16 inch thick. The bonding ribbon is attached to the cable or equipment by soldering or clamping. The ribbon or stranded conductor is preferred because of its flexibility, which is useful for placement in tight spaces of manholes, handholes and splice cases.

When placing cables in locations where the communications company will complete the bonding, leave enough ribbon to reach a communications company installed splice case or bonding ribbon.

### 18.4 Connection to Ground (Earth)

In general, the communications and power supply facilities occupy separate structures in the underground plant. Therefore, underground communications cables are not exposed to power contact, although indirect exposure to power lines is possible because the communications cables can become part of aerial or joint-buried plant.

**Note:** Joint-use scenarios with both power and communications located in the same manhole, handhole and vault should be avoided and discouraged wherever possible. See Section 16.2.1 for discussion of requirements for such joint-use manholes.

The maintenance of electrical continuity through the bonding schemes identified above provides adequate protection in the underground manhole if the bonding scheme includes a connection to the manhole grounding system.

Apart from conductive conduits/ducts connected into the manhole, a typical manhole grounding system can consist of several of the following elements arranged in an interconnected network:

- Rebar elements (metallic re-enforcing rods) within the cast concrete manhole walls
- Conductive metallic mounting hardware (e.g., Unistrut)
- A bare copper cable (e.g., size #4/0) positioned around the interior wall of the manhole
- Several (2 or more) driven copper clad steel ground rods outside of the manhole.

As noted above, it is important ***not to disturb*** any of these bonding or grounding connections or leave them disconnected after installation, construction, or maintenance work within the manhole or handhole.

For locations with driven ground rods, the grounding conductor to the ground rod shall be a minimum 6 AWG solid or stranded copper conductors. For such cases, it is convenient to have a ground bar (buss bar) located on



the side wall of the manhole (handhole) or attached to the cable support framework that provides the main connection point for the grounding electrode conductor to the driven ground rod. Such a ground bar provides multiple terminations for bonding conductors from each of the cables, closures and other network elements present. Therefore, individual bonding conductors can be lifted without disturbing the bonding/grounding connections of the other equipment.

In congested manholes where it is difficult to trace individual wires, the grounding conductors shall be equipped with a destination tag near the bus bar that identified the far end termination (cable, equipment closure).

The grounding conductor shall not be supported through fully closed steel (conductive) supporting rings. Rings made of nonmagnetic material (conductive or not) are preferred or steel “L” brackets are an acceptable means of supporting a grounding conductor.

The grounding conductors should be terminated at both ends with two-lug connectors, irreversible crimp-type connectors, exothermic welds or other connectors with anti-rotation designs to help prevent the connector from becoming loose (high resistance) over time.

All grounding conductors shall be installed as straight and short as possible. When changes in direction are necessary, bends shall have a radius no smaller than 12 inches, and the bending arc shall not exceed 90 degrees.

## 18.5 Bonding in Handholes

Handholes are plastic or concrete structures set below ground with their lids flush to the surrounding soil, turf, footpath or road surface; their use is more fully covered in [Section 21.5](#). These enclosures are used to house and protect communications cable splice points and to provide convenient access to, while safeguarding, cable termination and branch points. The handhole closures are usually open on the bottom with a 6-inch deep layer of gravel (pea gravel, #57 gravel or 3/4 inch aggregate) in the bottom.

The location and placing of bonding connections noted above in this chapter should be followed for handholes, with an exception for cables that are pulled through a handhole with no splices or opening of sheath that happens more widely in handholes since they are often used in cable deployments by directional drilling methods (see [Chapter 24](#)).

Where necessary for effective grounding of the communications circuits and closures, a driven ground rod (see [Chapter 25](#) for a full discussion of grounding means) is usually placed near one corner of the handhole (e.g., ~6-8 inches from walls) prior to adding the gravel layer.

## 19 Identification Markers for Underground Cable

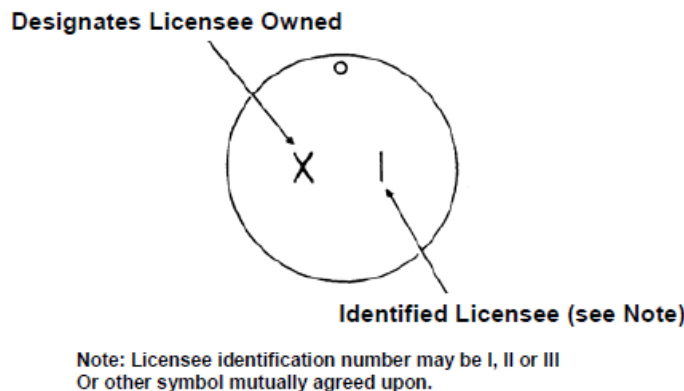
### 19.1 General

This chapter describes cable tags that can be used in a communications company manhole to distinguish licensee-owned cable and equipment from that owned by the communications company. Use of tags will also provide a means for determining ownership when more than one licensee has facilities in the same manhole and will minimize the possibility of craftspeople from one company accidentally opening cables owned by another company.

Each tag must be stenciled with an arrangement of letters and/or numbers that can be used as a code to designate ownership. The exact coding used to identify the owner shall be agreed to locally by the communications company. The communications company may also designate that additional letters or numbers be included on the tag to show other information they may desire to have recorded.

An example of how the ownership of a cable could be determined is shown in [Figure 19-1](#). The “X-I” label indicates that the cable is not owned by the primary communications company, where the suffix “I” number identifies the specific licensee. Where more than one licensee has facilities in the same manhole, each licensee’s cable will be identified by its assigned number on the tag. Even if only one licensee has facilities in the manhole, the letter “X” and the identification number must be stenciled on the tag to cover future growth.

**Figure 19-1 Cable Ownership**



The letters and numbers can be stamped on the tag by using stencils or other tools that will make a permanent identification on the tag.

The licensee owning the facilities may, if desired, attach additional tags to provide further identification of components or features of the system.

## 19.2 Description

Figure 19-2 shows examples of embossed sheet metal tags, and Figure 19-3 shows four types of tags with their dimensions that are used by the communications company.

**Figure 19-2 Examples of Metal Tags**



Any of these tags or any equivalent tag may be used if approved by the local communications company. The key functional performance features of any tag and its attachment hardware (e.g., lashing wires) are:

- Permanent with adequate resistance to water immersion and corrosive soil environments that are expected in the buried and underground plant.
- Sufficiently large print with adequate color contrast for easy readability in underground (low light) situations.
- Rounded edges and corners, i.e., no sharp points or edges that may cut or injure a technician.

## 19.3 Cable Tag Location

Licensee cables installed in communications company manholes must be identified in each manhole by a metallic or plastic cable tag. Tags must be placed on the cables between the point where they emerge from a duct and the first cable rack. A tag must be placed on lateral cables as well as on the main cable.

Where a licensee has more than one cable entering the same duct, it is permissible to wrap a wire around all the cables (bundle) and attach one tag at this point. When the cables are "bundled," it is not necessary to tag each individual cable.

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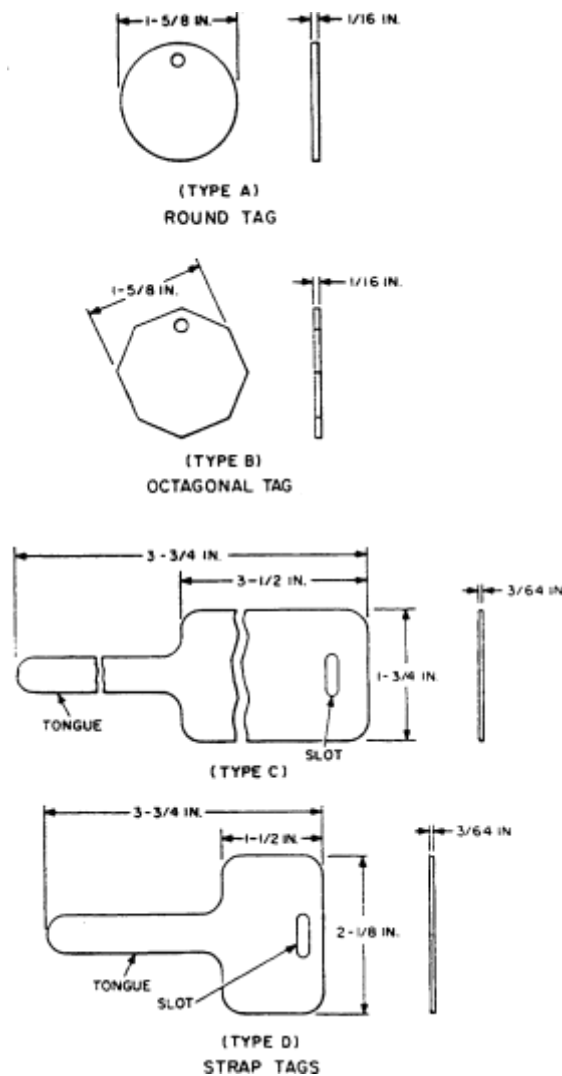
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## 19.4 Method of Installing Tags

Methods to install tags are:

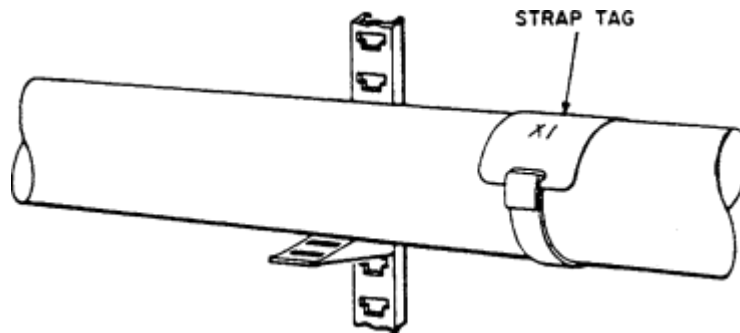
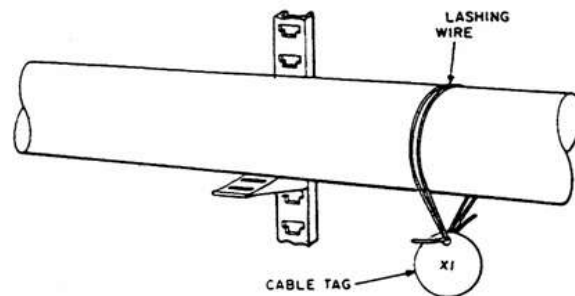
- The strap-type tag is placed around the sheath and the tongue is pulled through the slot and bent back on itself (Figure 19-4).
- The C-type strap tag (Figure 19-3) is used on cables having a diameter of 1 inch or more.
- The D-type tag (Figure 19-3) is used on cables with a diameter of less than 1 inch.
- The A- and B-type tags (Figure 19-3) are fastened to the cable using lashing wire threaded through the hole in the tag and twisted as shown in Figure 19-5.

**Figure 19-3 Cable Tags**

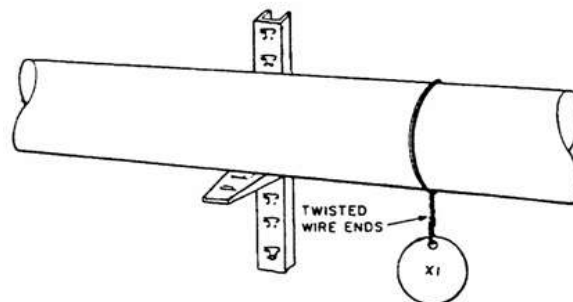


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**Figure 19-4 Strap-Type Tag Installed****Figure 19-5 Attaching Cable Tag With Lead Lashing Wire**

PLACE TAG WITH TWO LOOSE  
WRAPS OF LASHING WIRE



TWIST WIRE ENDS AROUND THE LASHING  
WIRE LOOPS TO SECURE TAG TO CABLE

## 19.5 Other Identification Markers

There are several types of tags and markers available made of UV-resistant polyethylene, polyvinyl-chloride and other plastics that were noted in [Chapter 11](#), along with the traditional metallic tags described above. The use of these alternate tags and wrap-around labels ([Figure 11-3](#)) in underground (manhole/handhole) locations is dependent on the label being resistant to submersion in groundwater and likely pollutants.

In congested manholes with many cables, it is important to be able to positively identify cables prior to cutting into them or opening splice cases. Orange-colored wrap-around labels and colored conduits can be very useful to distinguish cables providing the color is permanent after several years in the underground environment.

## 19.6 Locating Technologies for Buried and Underground Plant

Facility outages are a constant threat that looms over any excavation or construction project. One report identified the cause of 48% of service disruptions as being excavation damages. An accidental dig up results in a massive increase in expense which could have been avoided. The impact of an outage becomes even more severe as the networks grow in size, and customers (residential, commercial and industrial) become more dependent on these services, the impact of a facility failure becomes increasingly more critical.

Communications companies need detection systems to accurately map and locate their buried and underground facilities for repair and maintenance purposes and to help reduce accidental damage from excavation work because of inaccurately marked plant.

In general, no locating system is as accurate as one would like. In addition, the claims of many of the manufacturers for their equipment's abilities are usually derived under ideal conditions that are rarely met in actual field work and environments. However, the cost of the equipment continues to decrease and their accuracy tends to improve over time. The present procedures for locating facilities is sometimes described as an art, indicating that the accuracy of the locate is very dependent on the knowledge, experience and competency of the locating technician, as well as on their familiarity with the existing plant. The locator's abilities and knowledge is often the most important factor in an accurate locate.

Currently, accurate records of both the position and depth of the existing subsurface facilities are often not always available. Locating and re-recording all existing facilities would be very expensive and, therefore, opportunities offered during the installation of new facilities should be used to locate existing adjacent facilities to generate new records and/or update maps. Of the various methods used to aid in the detection of subsurface

utilities, the three most common methods are:

- Magnetometry
- Electromagnetic Detection (EMD)
- Ground Penetrating Radar (GPR).

These methods all utilize electromagnetic principles, but each has its own benefits and drawbacks.

**Magnetometry** detects permanently magnetized materials. It is relatively simple to use and requires very little training. However, it is limited to detecting ferrous materials because only significant gradients can be measured. Magnetometry devices are also prone to errors because of interference from above-ground structures.

**EMD methods** are able to detect all metals and, theoretically, aid in determining the location of subsurface non-metallic objects. By artificially inducing a secondary magnetic field in buried facilities through induction or direct contact, EMD instruments can locate these fields and thus determine their location based on peak or null readings. Also, through the conductivity characteristics of soil, although slight, EMD instruments are sometimes able to locate non-conductive objects. This is obtained simply by the lack of response detected from an EMD instrument of a non-conductive object. The downside of EMD technology is that it is unable to produce accurate depth readings and can also be susceptible to interference from above-ground structures.

Unlike EMD technology, **GPR instruments** utilize waves and not fields. GPR instruments send short wavelengths (microwaves) into the ground to detect objects. This technology is based on the reflection of waves (much like a bat using sound waves to navigate through caves). With many data collection points, a radar-gram can be formed, thus creating a three-dimensional representation of objects below the ground. The attractiveness of GPR technology is in its ability to detect multiple materials and its immunity to above-ground interference. Unfortunately, since GPR is based on waves, wave attenuation causes it to be severely limited by depth. Also, the data obtained is difficult to interpret, requiring a high skill level by the technician.

Benefits from accurate mapping of underground facilities include more efficient trouble-shooting analysis, more rapid location of buried splices, and more accurate records that will help improve network analysis and planned upgrades of a communications outside plant.

In general, recommendations and conclusions to help with the location of below-ground facilities include the following:

- Inclusion of tracer wires, electronic (EMD) markers, and/or warning tapes should be followed in all buried placements; particularly when all-dielectric facilities (fiber cables) are being deployed.

- Best practices of network providers/operators should include placement of electronic marking systems at buried splice locations for all-dielectric systems (fiber facilities) of significant size or service importance.
- GPR devices are typically quite large and expensive. If a communications company has implemented best practices to require the placement of tracer wires or markers with all-dielectric facilities, the use of GPR devices does not appear to be cost-effective.
- With new installations, Differential Global Positioning System (GPSs) should be used to accurately indicate and document the location of the new facilities. This information should be documented into an electronic database and mapping system that eventually contains all facilities. Whenever a locate occurs, information of the location of the located facility should be added to the central mapping system.

The GPS takes advantage of high-orbit U.S. government satellites deployed by the Department of Defense (DoD). A civilian grade receiver can monitor the signals emitted by the satellites and determine its position in latitude and longitude and altitude with an accuracy ranging down to less than 1 cm, depending on the quality of the receiver.

GPS receivers identify the user's location by measuring its distance from the GPS satellites to the receiver, and triangulation between itself and the satellites. Use of the GPS is now routine. Various techniques can obtain greater accuracy in GPS measurements, such as Differential GPS which uses a combination of a field receiver and a base station located at precisely known coordinates to enhance the precision and accuracy of the measurement. There are also statistical relationships that have been developed to increase the accuracy of a differential calculation for field receivers not "sufficiently close" to the base station.

In recent years, especially in some urban areas, an approach called Subsurface Utility Engineering (SUE) has become popular using a system of geophysical, civil engineering and land surveying practices to provide extremely accurate utility locating and mapping of utility facilities. These utilities can include water lines, optical fiber cables, communication lines, electric and other power lines, water lines, and gas lines.

This SUE approach using the Electromagnetic or EMD locators and GPR devices noted above, as well as sonic and seismic devices using sound and energy waves introduced into the ground or the utility itself, helps to further pinpoint the location of an underground utility on the earth's surface. For communications cables with copper pairs or metallic shields the detection process can be enhanced by transmitting an electrical signal of precise frequency along the metallic element, and then selecting the frequency with the EMD receiver.

One further step followed in the SUE approach is to complete a test hole with possible vacuum excavation to provide positive identification of the sub-surface utility. While the GPR and EMD locators can give us a very good idea of where the utility is, nothing beats opening a hole in the earth and



taking physical measurements of the utility's depth, width, and condition. The full analysis and use of these technologies has frequently been utilized at sensitive sites such as nuclear power plants and large industrial complexes where a single utility damage or outage can have widespread or even tragic consequences.

These location strategies can be applied to underground plant (see [Chapter 16](#)) and buried plant (Chapters [21](#) and [23](#)); particularly:

- During the directional drilling procedures discussed in [Chapter 24](#)
- For the optical fiber facilities deployment (FTTX) discussed in [Chapter 27](#)
- Where microducts ([Section 27.2, "Underground Cable Placement"](#)) are placed using standard buried plant techniques, as well as microtrenching procedures ([Section 23.5, "Microtrenching in Urban Environments"](#)).

## 20 Sealing Conduits and Ducts

### 20.1 General Definitions

1. **Conduit:** A structure containing one or more ducts. If it contains one duct only, it is called a “single-duct conduit.” If it contains more than one duct, it is called a “multiple-duct conduit.”
2. **Duct:** A single enclosed raceway of conductors or cables.
3. **Duct Bank or Conduit Run:** An arrangement of conduit providing one or more continuous ducts between two points.
4. **Conduit System:** Any reinforced passage or opening in, on, over, under or through the ground capable of containing communications facilities. This includes main conduit; underground dips and short sections of conduit under roadways, driveways, parking lots, railroad rights of way and similar conduit installations; laterals to conduits and into buildings, ducts, and manholes.
5. **Innerduct:** A semi-flexible duct (1/2-inch to 4-inch diameters), located in a conduit system to provide a means for compartmentalizing conventional ducts into multiple pathways for housing and protecting smaller cables. The innerduct term is widely used in the telecommunications industry but is not routinely used in the power supply industry.
6. **Microducts:** Small-diameter (~1/8 to 3/4 inch or 4-to-20 mm) products that are both thin- and thick-walled products that are now being widely used for the deployment of optic fibers and cables.
  - The thin-walled microduct products are designed for applications where fibers/cables are jetted (air-blown) into a conduit where the conduit provides the primary protection.
  - Thicker-wall microducts can have sufficient mechanical robustness and functional performance so as to require no further protection in certain direct-buried and insider premises applications.
  - Bundled microducts have several (typically between 2 and 24 at present) microducts combined together under a sheath(s), with variable cross-sectional shapes from a traditional circular (round) shape, to polygon shapes, to flat rectangular shapes that are developed to suit specific applications, environments, and user needs.
  - In-Living Unit (ILU) cable pathway products provide a small diameter cable pathway with an integral adhesive backing designed for use in occupied living and public spaces (e.g., hallways, living spaces, along stairs and between floors).

Communications providers will often use combinations of several ducts/innerducts in a conduit and, more recently, the wider use of bundled

microducts in conduits to maximize the efficient use of scarce conduit space. For example, three 1.5-inch diameter ducts or innerducts are often installed in a 4-inch diameter conduit.

As a general principle, where several ducts are available for use, the separate ducts and conduits should be segregated by cable type and technology with separate ducts for twisted pair copper cables, and optical fiber cables with a third duct/conduit reserved for future use. Using separate ducts and raceways for optical fiber cables and twisted pair copper cables is based on the different pulling tensions, bending characteristics, and abrasion resistances of these different cable types.

The reader should refer to GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit, and Accessories*, and GR-3155-CORE, *Generic Requirements for Single/Bundled Microducts and In-Living Unit (ILU) Cable Pathways*, for detailed descriptions, application notes, and functional performance criteria for these conduit, duct, innerduct and microduct products.

## 20.2 General Sealing

This section describes the requirements for duct seals, the materials used for sealing ducts and ductliners (innerduct), and the methods used to install the duct-sealing materials. The ends of ducts are sealed to prevent water and gas from entering buildings and to keep water out of ducts, particularly where there is a possibility of freezing.

There are several methods of making a permanent seal in the end of a duct using:

- Rubber duct plugs - These may be solid plugs to seal empty conduits/ducts or split plug design to fit between cables and conduit/duct.
- Caulking materials or more modern foaming materials.
- Combination of foam-plug with caulking or foaming materials.

Caulking and foaming materials cover a variety of water-blocking agents that are designed to seal active water leaks and to help prevent ingress of moisture, dust and particulates. Some of the traditional water-blocking and caulking products that have proven effective in the past include, but are not limited to, the following commercial products:

- Chemque Q-Pak 2000, Q-TEL 2027, 2032 and 2063 – Two-part polyurethane foaming agents with various types including fire-stop varieties (FR) that are often used in combination with foam or mineral wool strips.
- FST<sup>®</sup> Duct Seal (Polywater product) – A foaming formulation that expands and hardens into a void space defined by the placement of the

“damming” strips wrapped around the cables.

- Permagum (Virginia KMP) – Pliable polymeric material available as cords and tapes where one needs to help prevent the ingress of moisture, dust and dirt around edges and seals.
- Thoro® Waterplug – A blend of hydraulic cements, graded sands and additives supplied in dry powder form that rapidly hardens with water to form a plugging mortar.
- Scotchcast® (3M) Duct Sealing – A sealant foam that expands and hardens into a void space defined by the placement of the containment barriers inserted between cables and conduit/duct.
- STOPAQ® 2100 AQUASTOP – A waterplugging mortar that remains flexible after use and can be removed and possibly re-used.

Caulking materials may be used at all locations and must be used where the duct plug cannot be applied, with the necessary caveats that the caulking materials must be (a) compatible with the cable sheathing, (b) able to maintain at least an adequate waterhead for application (e.g., 20 feet for manhole and 10 feet for handhole) and approved by the communications company.

Many of the traditional caulking materials have fallen into disfavor because the older putty formulations were found to contain asbestos. As a result, new asbestos-free formulations have been developed such as Duraline (A-D Technologies) Hydra-Seal S-50 Putty Sealant, and the use of urethane foams has greatly accelerated with foam sealant materials, and many other foaming agents that can seal actively leaking holes.

**Note:** The products named in this document are supplied for informational purposes only. Ericsson - NIS does not recommend or endorse any particular company products or material formulations. Each communications company should have a list of approved materials and products for use in their networks and on the cables, conduits, ducts and other hardware. All these sealing and foaming materials should be evaluated and qualified by meeting product functional performance tests, which shall include:

- Waterhead-resistance testing of between 10-20 feet (e.g., depth of manholes)
- Gas-tight pressure testing to at least 10-15 psi levels
- Material compatibility tests to ensure sealing compounds do not adversely react with cable jackets, conduits, and metallic elements of the communications facilities
- Long-term performance testing to help ensure that foams retain their functional performance during long-term use in the Outside Plant (OSP) environment.

Detailed product functional performance may be found in documents such as GR-2847-CORE, *Generic Requirements for Cable Penetration Seal Assembly for CEVs and Manholes*, requires manhole and CEV plugs to be able to

resist pressures of 50 psi; while the walls of innerducts and conduits along with their associated connectors and couplings need to resist 50-125 psi, as described in GR-356 and GR-3155. The functional requirements in GR-3155 are based on the installation pressures reached during certain air-blowing cable installation methods. Rubber plugs designed for routine capping of conduits and ducts to prevent soil contamination and water intrusion are characterized by pressure withstand ratings in the 10 psi range.

Traditionally, the use of rubber duct plugs (split plug designs) was limited to vacant ducts or ducts occupied by only one cable, where the diameter of the cable met strict limitations dictated by available plug sizes. Current plugs are designed to accommodate multiple cables in a duct as long as the sizes of the plug, cables, and ducts are matched correctly and installed following the manufacturer's instructions.

For temporary use, wooden or plastic conduit plugs may be installed in the ends of ducts or at bends. Wooden plugs are often favored for vacant ducts rising up and terminating at the base of poles. For these applications, the wooden plugs are UV resistant, easily removed, and will only become tighter if swollen by water.

To properly install rubber duct plugs in an occupied duct, a split-conduit duct-plug wrench is required. To remove the plugs from an occupied duct, a split-conduit plug remover is required. These two tools are shown in Figures 20-1 and 20-2, respectively.

**Figure 20-1 Split-Conduit Plug Wrench**

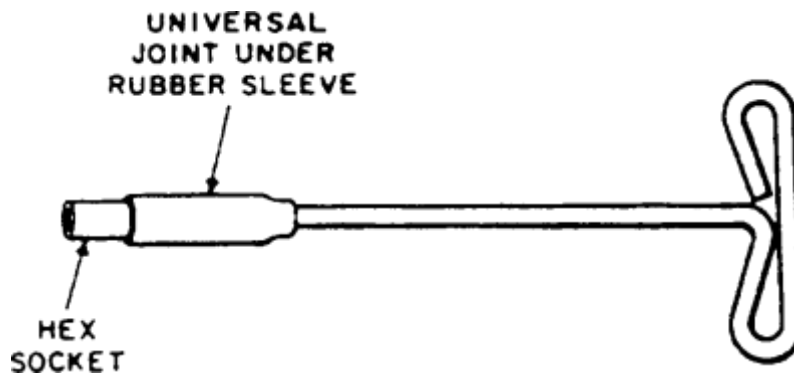
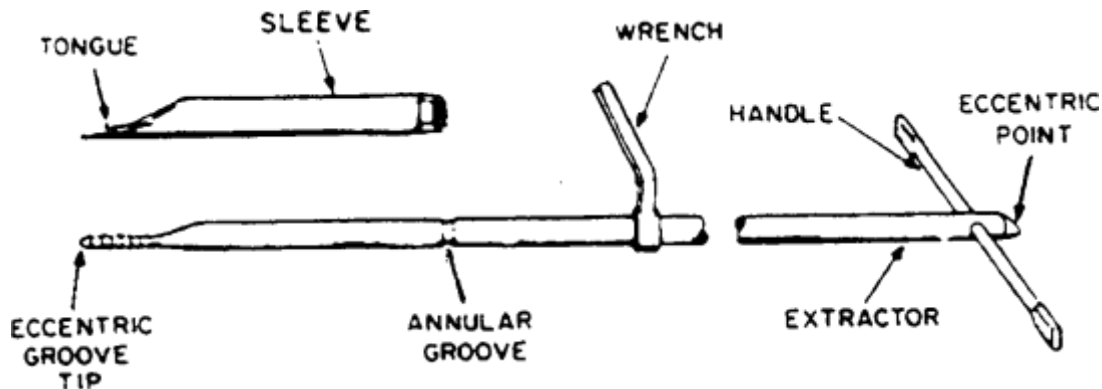


**Figure 20-2 Split-Conduit Plug Remover**

### 20.3 Where Seals Are Required

Generally, ducts connecting directly between manholes and buildings shall be sealed at both ends to prevent water and gas from entering the building and accumulating in the conduit system. One exception to this could be where gas exposure exists between the manhole and the building. Here, it may be advisable to seal the ducts at the building but omit the seals in the ducts entering the manhole.

In some circumstances, ducts/conduits may be left unsealed to permit the escape of storm and ground water through the system and therefore not accumulate and build up water pressure around the plant. The communications company will decide when the seals at the manhole can be omitted.

Ducts leaving a communications company manhole and terminating in a box or cabinet containing switches such as those used for traffic control, fire alarms, police boxes, or similar equipment must be sealed at both ends to minimize the hazard of gas explosions due to the arcing of the switches.

It is advisable to seal ducts that connect manholes to bends placed on poles, or on the outside of buildings at the pole or building. Sealing the duct will minimize the entrance of water and possibly prevent ice from forming in the bend during the winter months. Formation of ice in the bend can cause damage to a cable or impair the placing of a new cable. Because of the possibility of trouble from the formation of ice, when a licensee-owned cable is placed in a communications-company-owned duct that extends from a manhole and terminates at a pole or the outside of a building, the duct must be sealed at the pole or building. If the duct is owned by a company other than the communications company, it is the prerogative of the company owning the duct to decide if the duct will be sealed or left open.

The following are other locations where communications-company-owned ducts must be sealed at both ends:

- Ducts connecting one pole to another
- Ducts extending from a pole and terminating on the outside of a building
- Ducts extending from one building to another.

The following is a location where it is advisable to seal ducts/conduits in the underground plant (including handholes used in buried plant):

- Empty ducts/conduits to prevent accumulation of dirt and debris that will inhibit later cable placement.

The following are related above-ground or buried locations where it is necessary to seal ducts/conduits:

- Entrance facilities of Controlled Environmental Vaults (CEVs)
- Cable entrance facilities for huts and cabinets to help prevent water ingress, animal entry, and debris collection in the duct/conduit system.

Ducts that enter/exit above-ground pedestals should be individually evaluated as to the likelihood of them becoming a pathway for water or gas. In general, one should use caps on empty (spare) ducts and seals around cables in occupied ducts in these locations.

Damage to, or deliberately breaking into, an existing conduit introduces large risks associated with damage to the installed cable and compromising the seal integrity of the conduit run by allowing groundwater, rainwater, soils, or other contaminating soils or liquids into the conduit. If that conduit is sealed at the next access point, then the contamination (water or soil) will be trapped in the conduit around the cable. Therefore, as a general rule any entry point or branch point in a conduit run should be sealed.

## 20.4 Rubber Duct Plug - Description

There are two types of duct plugs: split plugs for sealing ducts occupied by a single cable, and solid plugs for sealing unoccupied conduit/duct. Although some designs of split plug can accommodate more than one cable, generally if more than one cable is placed in the same conduit or duct, sealing is most often accomplished with a caulking material (as covered in [Section 20.7](#) and [Section 20.8](#)).

Both the split and solid duct plugs are available in round or square shapes. Round plugs are used in conduits/ducts having a round bore, and square plugs are used in conduit/ducts that have a square bore.

The square and round solid rubber duct plugs ([Figure 20-3](#)) consist of a soft, expansible, rubber center section between two galvanized steel compression plates that are held together by a carriage bolt and a square nut. Tightening the bolt pulls the plates together, expanding the rubber and forcing it

against the inner wall of the duct to complete a seal. [Table 20-1](#) shows the type and size of duct plugs to use for the type of conduit involved.

**Figure 20-3 Solid Rubber Conduit Plugs**

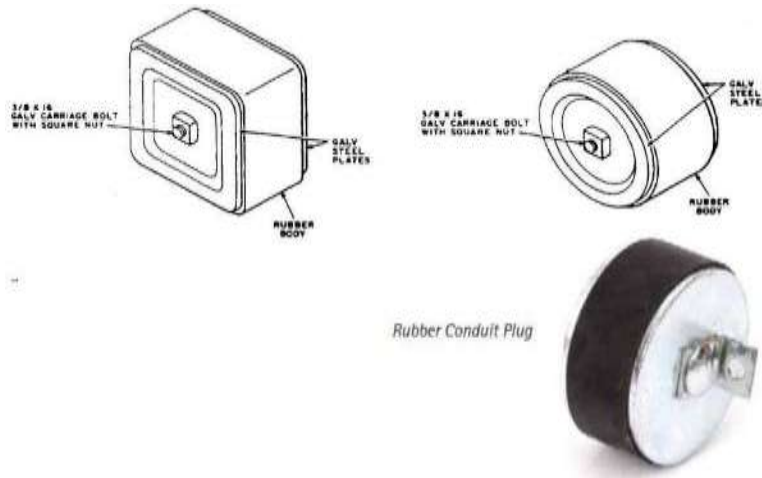


**Table 20-1 Solid Rubber Conduit Plugs – Dimensions**

| Type of Conduit     | Conduit and Plug Size |         |         |        | Type of Plug |
|---------------------|-----------------------|---------|---------|--------|--------------|
|                     | 3-inch                | 3¼-inch | 3½-inch | 4-inch |              |
| Plastic Pipe        |                       |         |         | X      | Round        |
| Steel Pipe          | X                     |         | X       | X      | Round        |
| Sewer Pipe          | X                     |         |         | X      | Round        |
| B or C Fiber        | X                     |         | X       | X      | Round        |
| B or C Cement-Fiber | X                     |         | X       | X      | Round        |
| B or C Concrete     |                       |         | X       | X      | Round        |
| D or E Concrete     |                       |         | X       | X      | Round        |
| F or G Concrete     |                       |         | X       | X      | Round        |
| Multiple Clay       |                       | X       |         | X      | Round        |

Split rubber plugs are designed with the rubber portion molded to fit cables of various diameters. The split plug has a diagonal cut in one wall of the rubber portion and sectional galvanized steel plates shaped to conform to the shape of the rubber to permit placing the plug over the cable. The rubber is compressed by using four 1/4-inch carriage bolts. Square split rubber plugs are shown in [Figure 20-4](#), and round split rubber plugs are shown in [Figure 20-5](#). The sizes of square split plugs are listed in [Table 20-2](#), and the sizes of round split plugs are listed in [Table 20-3](#).

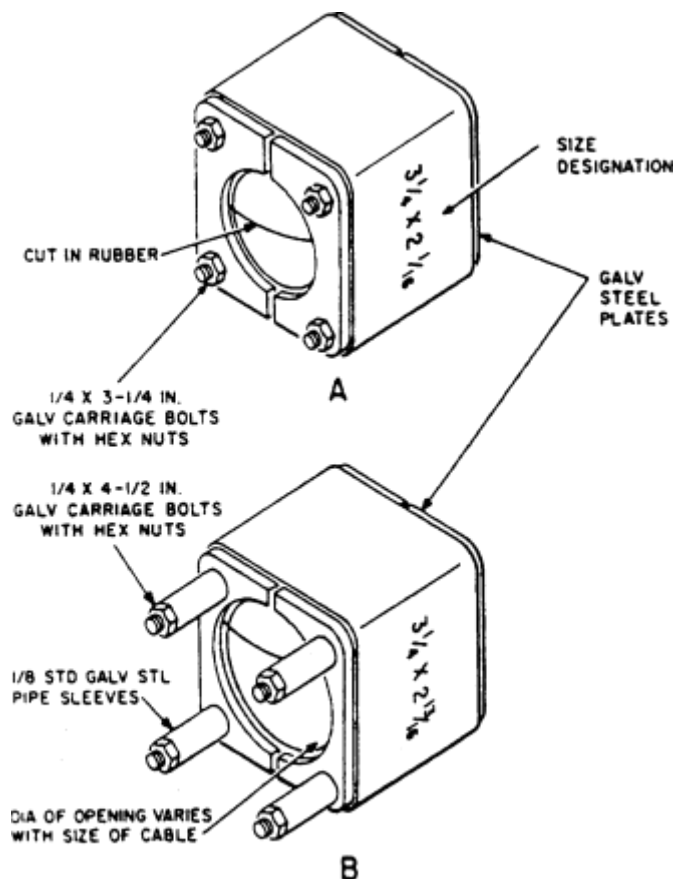


**Table 20-2 Square Split Rubber Conduit Plugs – Dimensions**

| Conduit Size in Inches<br>(See Note 1) | Cable Diameter in Inches (See Note 1) |         | Square Split Plug Data Dimension in Inches |         | Type of Design<br>(Figure 20-4) |
|----------------------------------------|---------------------------------------|---------|--------------------------------------------|---------|---------------------------------|
|                                        | Minimum                               | Maximum | Outside                                    | Inside  |                                 |
| 3-1/4                                  | 0.50                                  | 1.06    | 3-1/4                                      | 1-1/16  | A                               |
| 3-1/4                                  | 1.13                                  | 1.63    | 3-1/4                                      | 1-5/8   | A                               |
| 3-1/4                                  | 1.69                                  | 2.06    | 3-1/4                                      | 2-1/16  | A                               |
| 3-1/4                                  | 2.13                                  | 2.41    | 3-1/4                                      | 2-13/32 | A                               |
| 3-1/4                                  | 2.44                                  | 2.63    | 3-1/4                                      | 2-5/8   | A                               |
| 3-1/4                                  | 2.69                                  | 2.81    | 3-1/4                                      | 2-13/16 | B                               |
| 4                                      | 0.50                                  | 1.06    | 4                                          | 1-1/16  | A                               |
| 4                                      | 1.13                                  | 1.63    | 4                                          | 1-5/8   | A                               |
| 4                                      | 1.69                                  | 2.06    | 4                                          | 2-1/16  | A                               |
| 4                                      | 2.13                                  | 2.41    | 4                                          | 2-13/32 | A                               |
| 4                                      | 2.44                                  | 2.63    | 4                                          | 2-5/8   | A                               |
| 4                                      | 2.69                                  | 2.81    | 4                                          | 2-13/16 | B                               |
| 4                                      | 2.85                                  | 3.13    | 4                                          | 3-11/16 | B                               |

**Note** [1] Plug size is designated by conduit dimension and the maximum cable diameter for which the plug is designed. For example, specify a 4 x 2-5/8 inch square split-conduit plug for a 4-inch square bore conduit where the cable diameter is in the range of 2.44 to 2.63 inches.

The square split plug A in Figure 20-4 is used for sealing around all sizes of cables up to and including those of 2-5/8-inch diameter in a 3-1/4-inch square bore conduit. For sealing a conduit/duct containing a cable larger than 2-5/8 inches in diameter, the Type B plug shown in Figure 20-4 is required. The space is restricted between the cable and the conduit/duct wall because of the larger cable. Therefore, elongated bolts with pipe spacers on the Type B plug are required to make the nuts accessible to the split-conduit plug wrench.

**Figure 20-4 Square Split Rubber Conduit Plugs****Table 20-3 Round Split Rubber Conduit Plugs – Dimensions**

| Conduit Size in Inches<br>[See Note 1] | Cable Diameter Inches [See Note 1] |         | Square Split Plug Data Dimension in Inches |        | Type of Design<br>(Figure 20-5) |
|----------------------------------------|------------------------------------|---------|--------------------------------------------|--------|---------------------------------|
|                                        | Minimum                            | Maximum | Outside                                    | Inside |                                 |
| 3                                      | 0.50                               | 1.06    | 3                                          | 1-1/16 | C                               |
| 3                                      | 1.13                               | 1.63    | 3                                          | 1-5/8  | C                               |
| 3                                      | 1.69                               | 2.00    | 3                                          | 2      | D                               |
| 3-1/2                                  | 0.50                               | 1.06    | 3-1/2                                      | 1-1/16 | C                               |
| 3-1/2                                  | 1.13                               | 1.63    | 3-1/2                                      | 1-5/8  | C                               |
| 3-1/2                                  | 1.69                               | 2.06    | 3-1/2                                      | 2-1/16 | C                               |
| 3-1/2                                  | 2.13                               | 2.44    | 3-1/2                                      | 1-7/16 | D                               |

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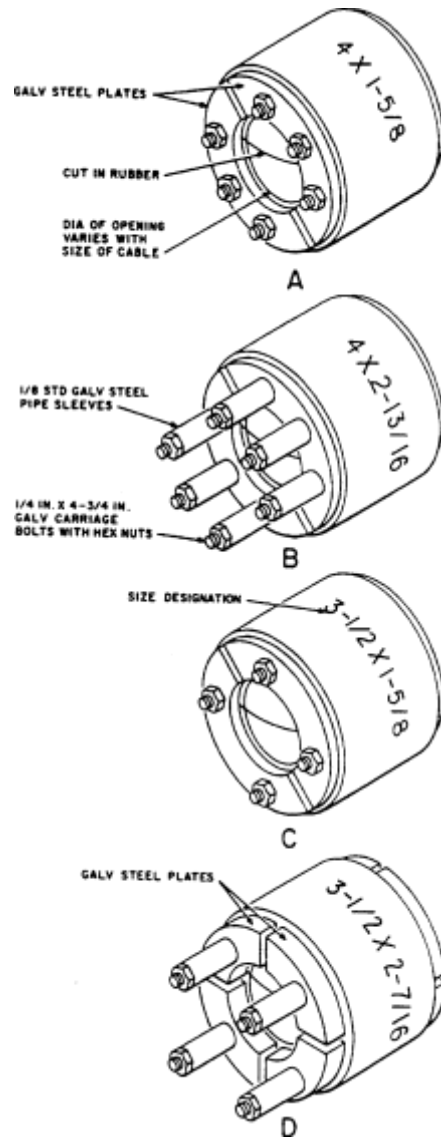
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| Conduit Size in Inches<br>[See Note 1] | Cable Diameter Inches [See Note 1] |         | Square Split Plug Data Dimension in Inches |         | Type of Design<br>(Figure 20-5) |
|----------------------------------------|------------------------------------|---------|--------------------------------------------|---------|---------------------------------|
|                                        | Minimum                            | Maximum | Outside                                    | Inside  |                                 |
| 4                                      | 0.50                               | 1.06    | 4                                          | 1-1/16  | A                               |
| 4                                      | 1.13                               | 1.63    | 4                                          | 1-5/8   | A                               |
| 4                                      | 1.69                               | 2.06    | 4                                          | 2-1/16  | A                               |
| 4                                      | 2.44                               | 2.63    | 4                                          | 2-5/8   | A                               |
| 4                                      | 2.69                               | 2.81    | 4                                          | 2-13/16 | B                               |

**Note** [1] Plug size is designed by conduit/duct dimension and the maximum cable diameter for which the plug is designed. For example, specify a 4 x 2-13/16 inch square split-conduit plug for a 4-inch round bore conduit where the cable diameter is in the range of 2.69 to 2.81 inches.

Four (4) types of round split plugs are shown in Figure 20-5. Types B and D are for larger-size cables where the space between the cable and the duct is so limited that elongated bolts are required to permit the use of the split-conduit wrench. Table 20-3 relates the sizes of round split duct plugs that can be used with the different sizes of ducts when occupied by cables of various outside diameters.

When the outside diameter of the cable exceeds the dimensions shown in Table 20-3 for any given conduit/duct size, a sealing material is required to make a plug.

**Figure 20-5 Round Split Rubber Conduit Plugs**


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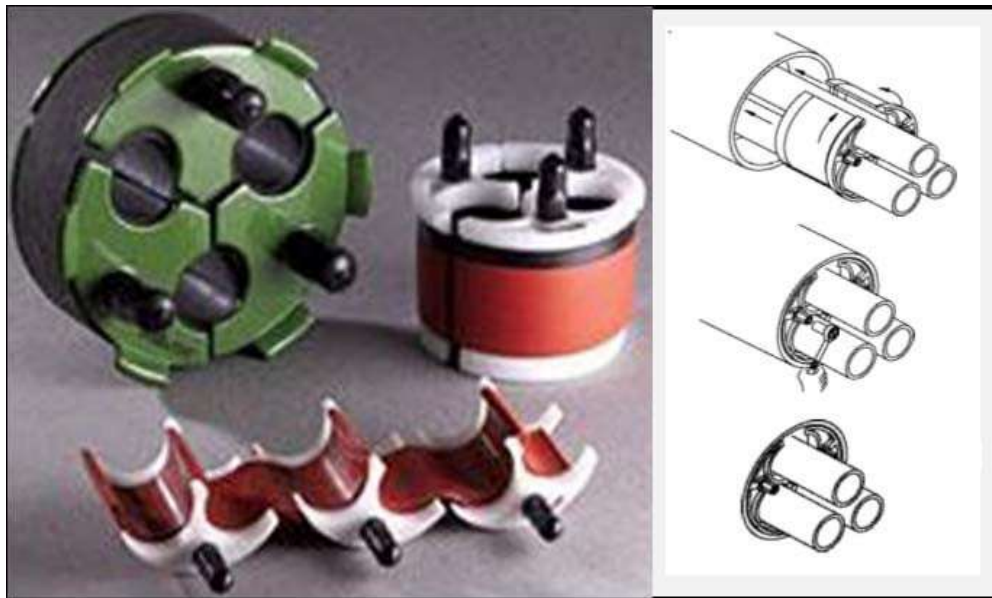
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### 20.4.1 Rubber Duct Plugs for Multiple Cables in a Conduit

Split plugs are available for sealing around, organizing, and supporting several (3-5) ducts, pipes, or cables in a conduit. The plugs are usually designed for use in round openings such as conduits, conduit fittings, and core-drilled wall penetrations, with triplex (3) or quad (4) versions the more commonly used (see triplex example in [Figure 20-6](#)). These split plugs are usually designed for a standard 4-inch diameter conduit with a range of round openings to accommodate 1/2-inch to 2-inch diameter cables.

**Figure 20-6 Example - Triplex Split Plug**



The preferred designs for these plugs should include a split design to allow for retrofitting without disassembly of the entire plug, and expandable flexible gaskets to allow for expansion and contraction of cables or sub-ducts without leakage. The rigid edges of the plug provide a strong anchor point to the conduit (or duct) while the flexible gasket material prevents cable abrasion.

## 20.5 Installing Rubber Duct Plugs

Before installing rubber duct plugs, remove dirt, grease, or loose material from the area at the end of the duct. The plug should also be free of any dirt or grease. For installing:

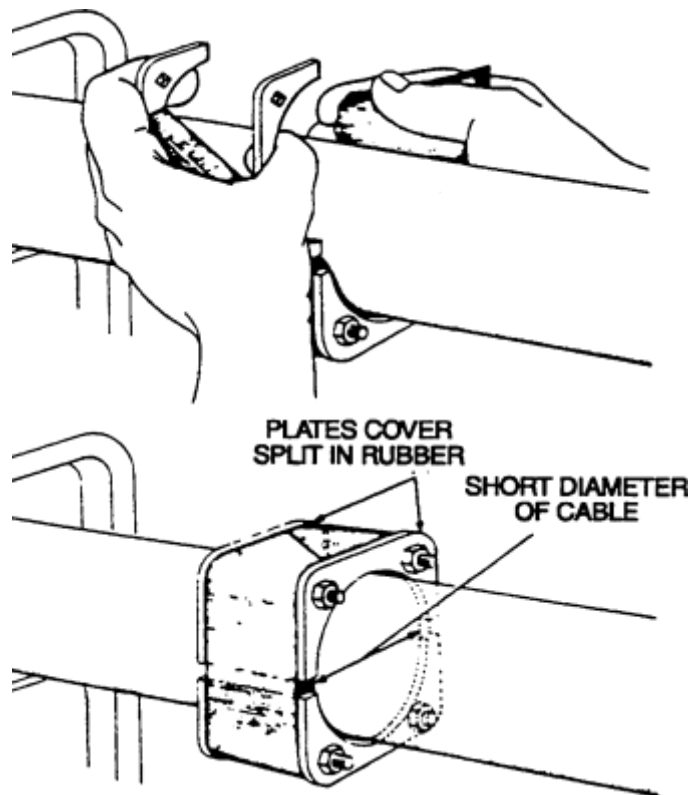
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- ***Solid Rubber Plugs:*** Insert the plug far enough into the duct to clear the bevel and be beyond any cracks or chipped areas. Turn the square nut until the rubber is expanded firmly against the conduit wall. Avoid tightening to a point where the rubber bulges out around the edges of the compression plates. This excess pressure can crack the duct wall.
- ***Split Rubber Plug:*** Inspect the cable for any deep kinks just inside the duct. If a kink exists at this point, try to insert the plug further into the duct. If the kink cannot be avoided, use a sealing material instead of a duct plug. To place a square split plug on a cable, remove one of the bolts holding the plates that cover the split in the rubber. Swing these plates on the other bolt to uncover the split in the rubber. Evenly spread the rubber as shown in Figure 20-7 and slip the plug over the cable. Restore the plates to the proper position and replace the bolt and nut. Slide the plug along the cable into the duct until it is flush with the inner edge of the bevel and clear of any breaks or chips extending into the bore.

**Figure 20-7 Placing Split Rubber on Cable**

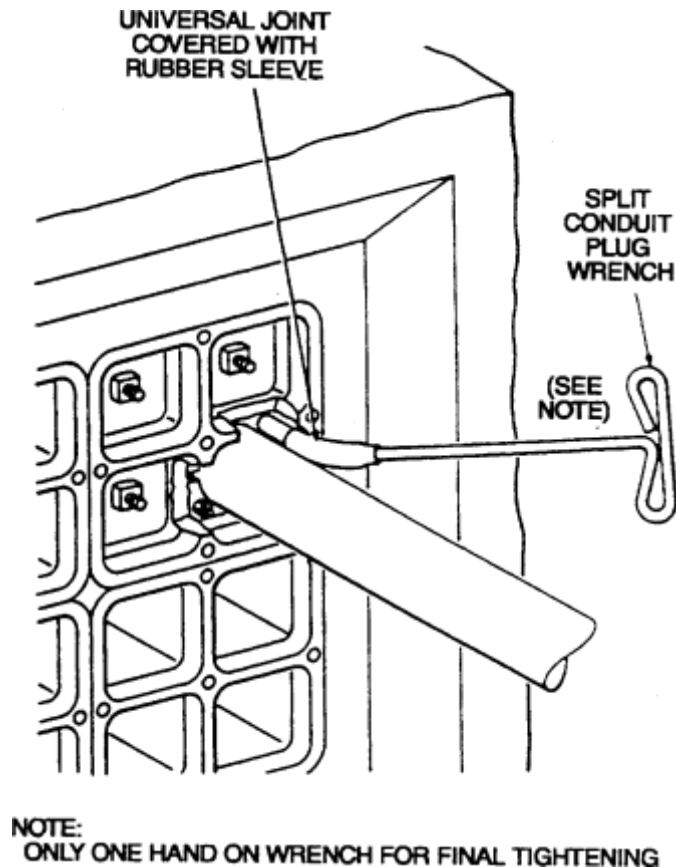


When placing a round split plug with four steel plates at each end (Figure 20-5, Type D), temporarily remove the bolt that passes through the split in the rubber.

Plugs equipped with elongated bolts must be inserted into the duct far enough to make the seal, and yet have the nuts outside the face of the duct when the plug is fully compressed.

Tighten the nuts with the split-conduit plug wrench (Figure 20-8) by turning down each nut a little at a time to maintain uniform pressure on all sides. When all nuts are equally tightened, make the final tightening using the maximum effort with *only one hand* on the wrench.

**Figure 20-8 Tightening Plug with Plug Wrench**



## 20.6 Removing Rubber Duct Plugs

Perform the following steps to remove solid or split rubber plugs:

- ***Solid Rubber Plugs:*** Remove the solid plug, back off the nut a few threads to relieve the compression of the rubber and withdraw the plug. If relieving the pressure does not restore the rubber to its original size, or if the rubber adheres to the walls of the duct, it will be necessary to apply force to the plug to work it loose. This can be done either by unscrewing the nut until about half of the threads in the nut are exposed and screwing another bolt into the exposed threads to act as a handle, or by twisting a piece of steel construction wire under the nut and attaching a prying lever to this wire.
- ***Split Rubber Plugs:*** Remove the split rubber plugs, remove the nuts and outside plates from the plug and push the bolts all the way back through the holes in the rubber to free the back plates from the rubber.

If the plug has been in place for only a short time, it can sometimes be removed by using long-nose pliers to grip the rubber through one of the holes near the cut and “peeling” it from around the cable. If this is not successful, use the split-conduit plug remover.

To remove square or round split-conduit plugs with the split-conduit plug remover, use the following procedure:

1. Insert the tongue of the sleeve between the rubber and the duct wall at the hole in the free end of the rubber near the cut as it appears in the face of the plug. See [Figure 20-9](#).
2. Push the tongue of the sleeve to its full depth between the rubber and the duct wall. It may be convenient to insert the handle end of the extractor into the sleeve to provide an extension for a firmer grip.
3. Assemble the wrench on the extractor and pass the extractor through the sleeve. Turn the eccentric point on the handle end of the extractor, which is in line with the grooved tip, toward the center of the duct. This will place the tip approximately in line with the bolt hole in the rubber.
4. Press the extractor forward until the tip is completely embedded in the rubber. This position is reached when the annular groove in the extractor shaft is even with the end of the sleeve. See [Figure 20-10](#).
5. Engage the wrench with the hexagonal end of the sleeve. Using the wrench, hold the sleeve to prevent it from turning while rotating the extractor one half turn. This causes the tip of the extractor to grip the rubber between it and the tongue of the sleeve. The eccentric point on the handle end will be toward the corner of the duct when the grip is fully tightened. [Figure 20-11](#) shows the extractor being tightened in the rubber prior to removal.



6. Slide the wrench back against the handle of the extractor. Gripping both the wrench and the extractor, pull gently on the extractor while shaking the cable slightly until the plug separates at the cut and starts to come out. As the pulling is continued, the rubber will stretch and tend to unwrap from the cable. See [Figure 20-12](#).
7. If the rubber adheres to the duct or cable and makes removal difficult, release the grip on the rubber, disassemble the tool, and reinsert the tongue of the sleeve in several places around the duct to break whatever bond exists. Then reassemble the tool in the plug and resume pulling.
8. As the rubber emerges from the duct, move the tool around the cable while pulling on the rubber so that the tool will be opposite or slightly ahead of the point where the rubber is emerging.
9. After the rubber has fully emerged, remove all the bolts and the two back plates of the plug and reassemble the plug.

**Figure 20-9 Inserting Remover Sleeve**

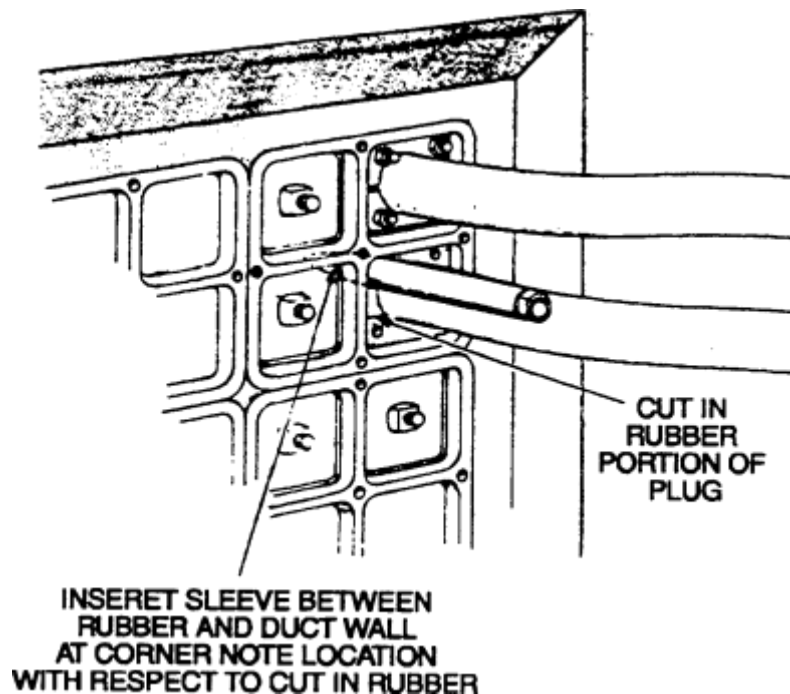
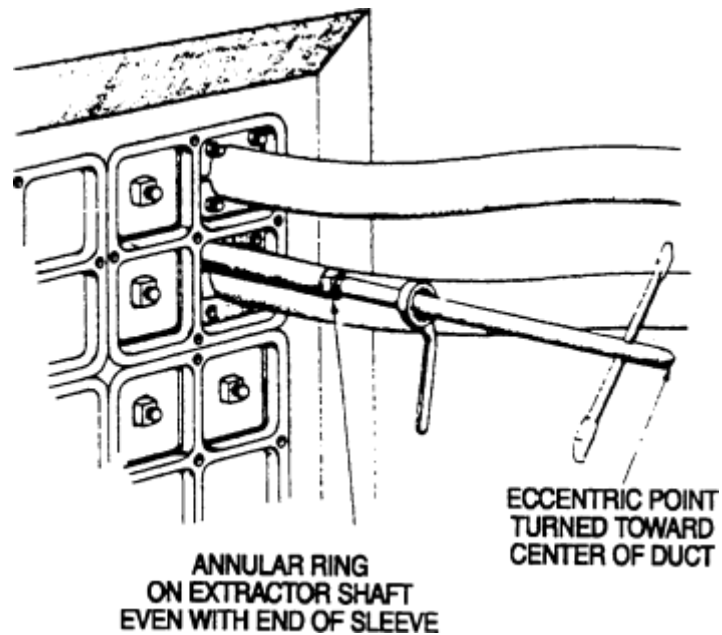
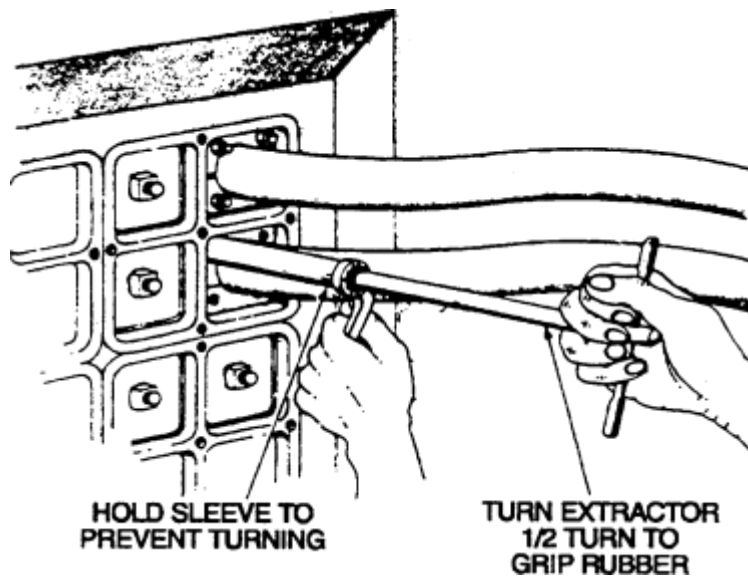
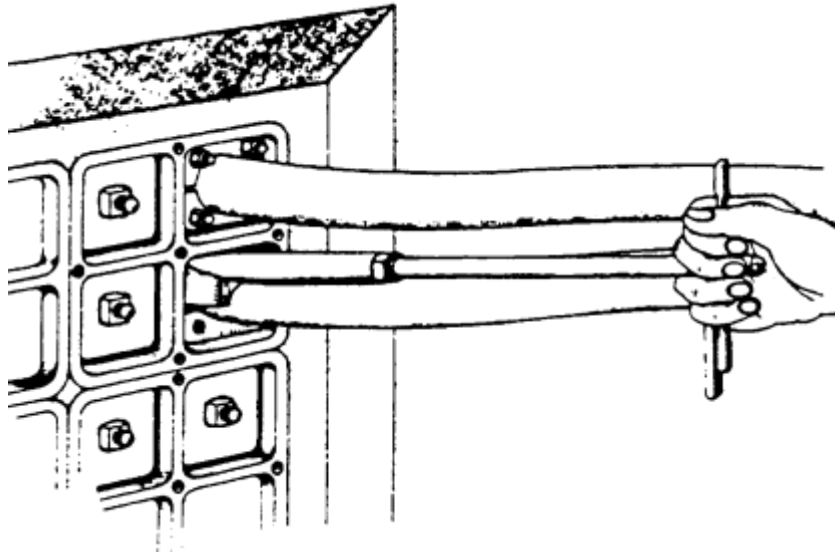


**Figure 20-10 Inserting Extractor****Figure 20-11 Engaging Rubber with Extractor**

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**Figure 20-12 Removing Split Rubber Plug**

## 20.7 Description of Caulking Materials

Commercially available caulking materials have provided suitable seals in the past for the end of conduits and ducts.

Some caulking materials may contain chemicals that are harmful to certain types of plastic sheath. It is advisable to check the manufacturer's recommendations and the communications company before purchasing the material. Each communications company has a list of approved materials and products for use in their networks and on the cables.

When a licensee-owned cable is placed in a duct occupied by a communications company cable, an approved caulking material must be used to seal the duct. If a licensee-owned cable is the only cable in the duct, the licensee may select any duct-sealing material approved by the communications company.

The procedure below ([Section 20.8](#)) is written around the *Waterplug* material product noted above, but the general principles expounded apply to whatever caulking material is used. The manufacturer for whatever caulking material is used should supply instructions, precautions and documentation pertaining to the proper and best use of their products.

## 20.8 Installing Caulking Material

**Duct Preparation:** Clean all surfaces of the cable and the duct that the *Waterplug* material will contact in making the seal. The cable must be located as close to the center of the duct as possible. Centering the cables can be done by using some type of spacer. Figures 20-13 and 20-14 show a serving tape being used as a spacer.

**Figure 20-13 Serving Tape Used as a Spacer**

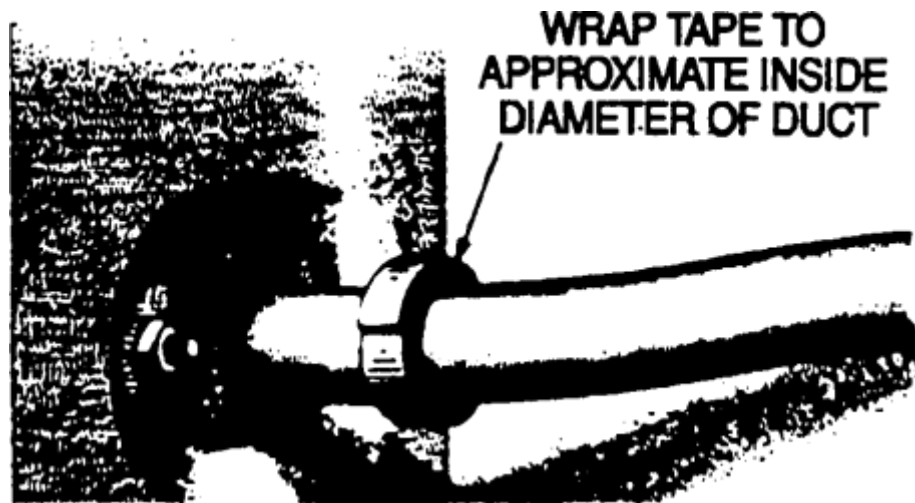
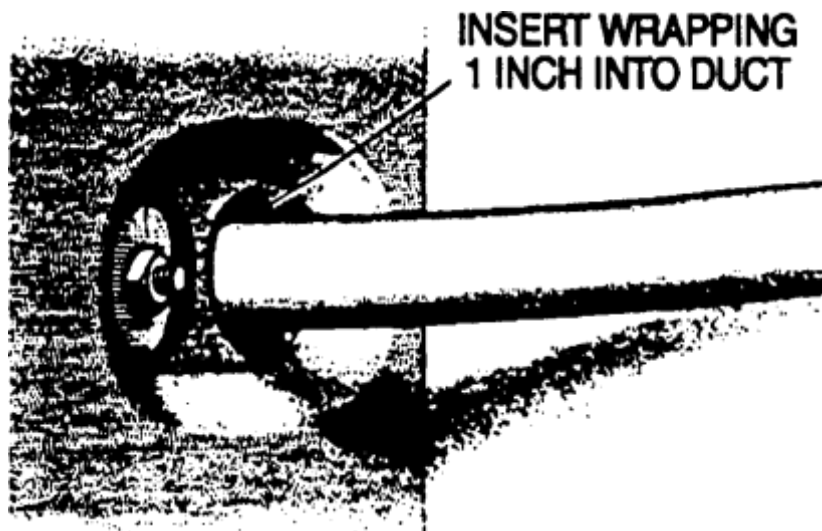


**Figure 20-14 Serving Tape Inserted in a Duct**



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The “some type of spacer” noted above can be a traditional lead-serving tape, or other generic tape products such as:

- Aluminum tape with adhesive on one side
- CR or DR tapes consisting of a 2-ply black tape, with vulcanized rubber on one side and adhesive on the other
- B Sealing tapes that are tacky black sticky tapes
- Lead serving tape that was traditionally used to patch lead cable sheaths
- Trac Tape - used to fill voids between side-by-side cables entering a closure.

Although these tapes are useful for centering the cable in the conduit/duct, the water and gas seal should be achieved with the other materials and products mentioned in this chapter that are specifically designed and approved for the purpose.

If the cable can be held centered in the duct by a sling or other means, a backing of paper or other waste material is required to confine the flow of the *Waterplug* material. The backing must be inserted into the duct approximately 1 inch from the face of the duct.

Mix the *Waterplug* material until it reaches the consistency of putty. The mix will set in 2 or 3 minutes.

Apply the mixture to the duct, working it firmly against the wall and the cable. Finish it off even with the face of the duct, or if a cable is present, and bevel out toward the cable.

If water is running from the duct, apply *Waterplug* material first to the upper portion of the space to be filled, leaving a small opening at the bottom through which water can flow to avoid building up water pressure until the *Waterplug* material first applied has set. After a few minutes, mix a small quantity of *Waterplug* material and shape it by hand in the form of a conical plug. When a sudden warm feeling and a dry appearance come over the mixture, apply it to the opening below. Force the material well into the opening and exert pressure against the plug for a full minute or longer until the flow of water has stopped. After a few minutes, the surface can be smoothed off with a sharp trowel or chisel to conform to the remainder of the seal.

If the water pressure is heavy, as when a duct is full of running water, it is better to seal a vacant duct with a solid rubber plug instead of trying to seal it with *Waterplug* material. Under the same condition in an occupied duct, the flow of water can be sufficiently slowed to permit a *Waterplug* seal to be made by using part of the rubber portion of a split plug as a dam. Cut the rubber in half across the length of the plug and place a half-section around the cable. Lift the cable and push the rubber into the duct to the depth required for the *Waterplug* seal.

**Removal:** The *Waterplug* material can be removed from ducts by sharply striking the seal with a hammer or by using a hammer and a cold chisel, or other type of cutting tool, to crack the seal. After the seal is fractured, the pieces can be removed from the duct.

## 20.9 Installing Plastic Duct Seals

The duct surfaces and the cable must be clean and dry before applying plastic duct or conduit seals.

To seal the cable in a vertical position, as in bends at poles or at the top of riser pipes, roll a quantity of the materials between the hands to form a rope slightly larger in diameter than the space to be filled. Wrap the material around the cable and, while holding the cable centered in the duct, force the duct seal into the duct to a depth of about 2 inches. Apply successive lengths of the materials, forcing them firmly into position, until the space is sealed to the top of the duct. Bevel the top of the seal, sloping it slightly upward from the edge of the duct to the cable.

When sealing cable in a horizontal position, lead-serving tape may be used to center the cable. The tape must be inserted 2 inches into the duct.

## 20.10 Wooden Duct Plugs

Wooden duct plugs can be used for temporarily sealing ducts during conduit construction as protection against silt, or to prevent stones and other foreign material from getting into the ducts during the interval between the completion of the conduit work and the cable placing. They may also be used to plug vacant bends that are terminated at a pole or against the outer side of a building wall.

Wooden plugs are available in several types and sizes for use with the various types and sizes of ducts and cast iron or plastic bends.

Wooden plugs are tapered and are installed by tapping them into the bore of the conduit. If a better fit is required, they can be wrapped with cheese cloth or muslin. Wrapping the plug permits a better seal and reduces the distance the plug has to be driven into the bore to achieve an adequate seal. Plugs installed in the end of a clay duct must always be wrapped.

## 20.11 Plastic Conduit Plugs – Description and Use

The 4-inch Universal Plug shown in [Figure 20-15](#) (as pictured from Underground Products, Inc.) is a tapered, black, polyethylene plug. It is suitable for use in any type of 4-inch diameter, round-bore conduit, and is designed to prevent the entrance of fluid and debris from the manhole into the duct.

The tapered end of the 4-inch Universal Plug is inserted into the bore of the duct and firmly pressed home by hand.

**! CAUTION !** Do not use a *mallet, hammer, etc.*, to drive the plug into the duct bore.

The Universal Plug is not designed to withstand a head of water that would develop within the conduit structure from conduit breakage, leaking joints, etc.

**! CAUTION !** Do not use the plug in manholes, cable walls, buildings, etc., where the entering ducts are required to remain sealed against *water pressure or gas.*

Figure 20-15 4-Inch Universal Plug



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## 20.12 Duct Plugs Using Foams

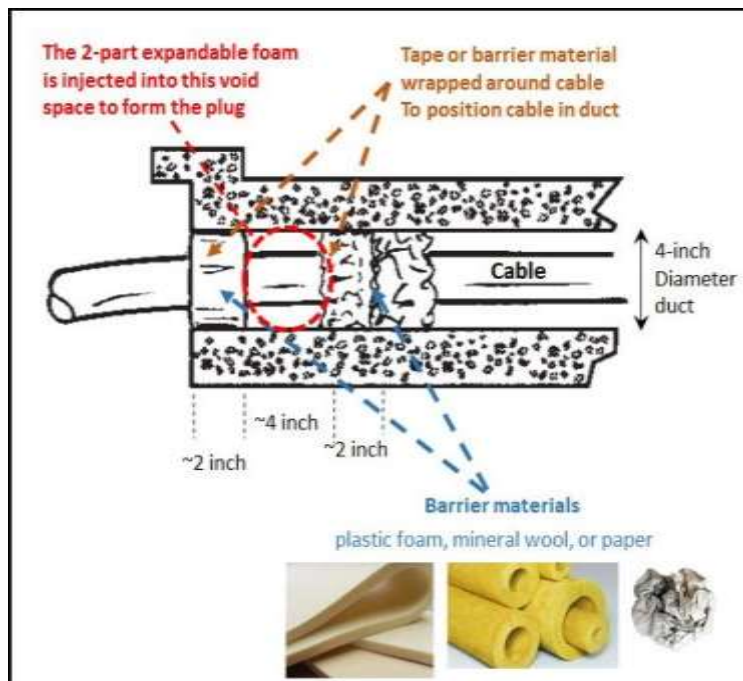
The use of foams in duct plugging and the construction of fire stops inside buildings are widely used and can be equally used in outside plant construction. These foams are formed at the work location by mixing two compounds together and injecting to the space between cable and duct. As the foam forms, it expands into the interstices around the cable and into the duct/conduit inner surface, creating an effective seal (water and gas seal).

Foams can provide some flexibility advantages over the plug products since the right size plug may not always be available, and it may not be convenient to return to an installation to re-tighten mechanical elements that may have loosened as result of compression set of the sealing portion.

The foaming products (e.g., as listed in [Section 20.2](#)) are usually two-part mixtures that are provided as an injectable material in a dispenser kit with:

- Front and back barrier materials consisting of paper, foam or mineral wool strips
- Push rod to place the rear barrier material at least 4-6 inches into the duct
- Dispenser-plunger and nozzle – some products have the 2-part foaming plug material integrated into the plunger/dispersing tool
- Tape or wraps to help position cable in the center of duct
- Disposable gloves to minimize contact with the foaming materials.

**Figure 20-16 Schematic of Foam Duct Plug**



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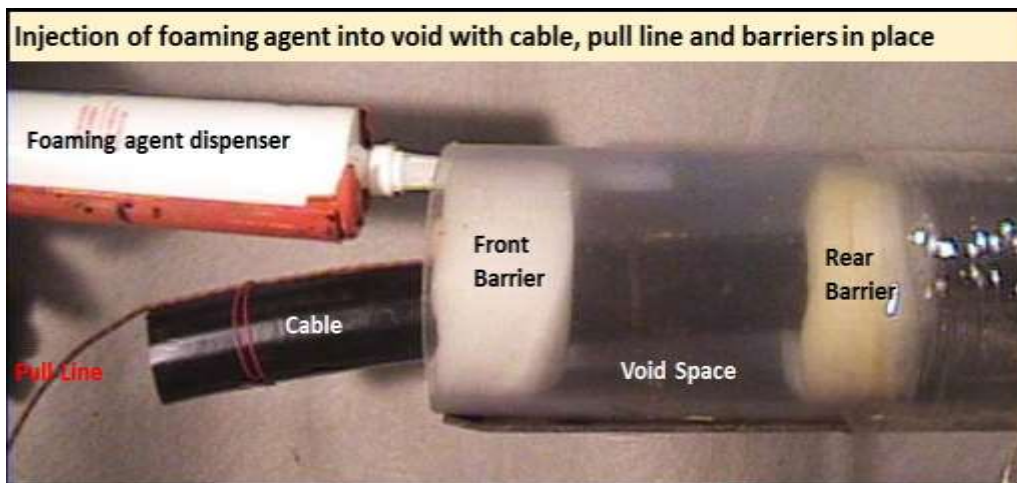
Any duct sealing and installation should be done in accordance with the specific product instruction sheet and be governed by all applicable safety and regulatory practices in effect in the jurisdiction in which the work is performed.

Experience has shown that a cable duct can be reliably plugged against water and gas using around four (4) inches of foam.

In a vacant duct/conduit, the open end is cleaned to a depth of six (6) inches, and the rear barrier strip is coiled and pressed into the duct, leaving a six (6) inch area open. The rear strip prevents the foam from creeping up the duct where it might be difficult to remove when placing in the duct. The second barrier strip is then coiled and placed so that the outer edge is flush with the outside edge of the duct, leaving a small hole at the top as an entry point for the dispenser nozzle.

In occupied duct, the practice is essentially the same in cleaning and placing the front and rear barrier strips. Additional barrier materials can be pushed with the rod around the multiple cables or sub-ducts present. Make sure to keep the cables/sub-ducts as centered as possible in the conduit during this process. For vacant ducts or in some cases where a single cable is present, there may be a loop of a pull line or tape that may be left in the conduit for later use. [Figure 20-17](#) illustrates the general configuration of the cable, barriers, pull lines and so forth at the time of injection of the foam.

**Figure 20-17 Example of Foam Injection Step**



When mixed and injected, the foam expands and hardens, keeping water, acids, greases, gases, insects, and rodents, etc., out of the conduit. The approved foaming agents should have good wetting and adhesion to the metals, plastics, and concrete materials found in the communications conduits, ducts and cable components.

The placement of the barrier (or “damming”) strips wrapped around the cables helps create the void into which the foaming material is injected and holds the rapidly expanding foam in position while it cures. The placement of the “damming” or barrier strips wrapped around the cables creates the void into which the foaming material is injected and holds the rapidly expanding foam in position while it cures.

If fire-stopping materials are also required for a location, the front barrier material is removed after the foaming reaction has concluded and the foam is solid in the void. The approved firestop material can then be used to fill the space where the front barrier was located.

### 20.13 Ductliner (Innerduct)

All unused innerducts must be capped with 1-1/2-inch B or C caps, or with the plugs furnished with the innerduct and the innerduct racked along the same path as the occupied innerduct. The occupied innerduct must be sealed with an approved plug of the correct size to fit the occupying cable. These plugs may be obtained from the innerduct manufacturer or the communications company.

Conduit occupied by innerduct(s) that feed Cable Entrance Facilities (CEFs) or Controlled Environmental Vaults (CEVs) must be sealed at both ends. Where there is one innerduct, seal the conduit with a standard conduit plug. Where more than one innerduct has been placed in a single conduit, seal the space between the innerducts and the conduit with B duct sealer, *Waterplug* or an equivalent caulk material, or other communications company approved methods and materials.

Screw-in expandable rubber seals are available for temporary sealing of innerduct during installation.

### 20.14 Microducts

As broadband deployments and overbuilds proceed, other innerduct type products such as small diameter microducts and flexible lightweight fabric sleeves containing pull tapes have been introduced to maximize the use of the available space in ducts and conduits.

The microducts come with a range of appropriately sized and designed accessories including seals and plugs.

The collapsible fabric products are engineered with a low coefficient of friction so that low cable pulling tensions can be used as well as being available in various configurations including multiple cells (1, 2, or 3), with or without pull tape, self-supporting and different colors. Individual cells will accept up to a 1-inch diameter cable that can provide flexibility for local

distribution, service drop plant, and intra- building applications.

The open structure of fabric sleeves can allow entry of water, dirt, soil, and other particulate contamination into the cable pathway, causing problems during later cable installation. Although such fabric sleeves can provide a cable pathway inside straight new conduit runs between manholes, the sleeves can have trouble snaking their way through conduits with numerous bends (such as often happens with conduit runs into and around customer buildings). Fabric sleeves that have been deployed in older conduits that may have an accumulation of soil, pebbles, water, and mud inside them will often not be readily usable as a good cable path.

The smooth and corrugated ducts, as well as various types of microducts, provide the preferred means to insert separate smooth cable pathways into a conduit. The microducts come with a range of appropriately sized and designed accessories, including seals and plugs. As noted in [Section 20.1](#), there are a variety of microduct products providing small-diameter (~1/8 to 3/4 inch) pathways for small cables and individual fiber jumper cables. The varieties include both thin- and thick-walled products that are now being widely used for the deployment of optic fibers and cables. The microduct product line and applications are discussed fully in [Section 27.2.7 of Chapter 27](#) on FTTx.

In terms of sealing the microducts, it is imperative that any vacant (empty) microduct should be sealed with the caps and plugs, as per the manufacturer's instructions. If sufficient amounts of dust particles or soil are allowed to enter and accumulate in the small diameter microducts, the cable pathway will be compromised. Once cables or fibers are deployed through the microducts, they should be sealed and protected just like the innerducts, cables, and sub-ducts discussed earlier in this chapter.

## 20.15 References Related to Conduits, Ducts, Sealants and Encapsulants

1. GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit and Accessories*.
2. GR-3155-CORE, *Generic Requirements for Single/Bundled Microducts and In- Living Unit (ILU) Cable Pathways*.
3. GR-2847-CORE, *Generic Requirements for Cable Penetration Seal Assembly for CEVs and Manholes*.
4. TR-NWT-000354, *Generic Requirements for Reenterable Encapsulants*.

## 21 Buried Plant Construction - General

This chapter outlines construction and maintenance procedures to be followed when two or more parties bury their facilities in a common trench. It must be pointed out that the procedures outlined in this chapter may vary from those covered by a formal Buried Agreement entered into between the communications company and the Cable Television (CATV) company, the power company, and other affected parties. In such cases, the terms and conditions of the Joint-Use Agreement (JUA – see Chapter 26) shall apply.

**Note:** Information on vertical risers and U-guards was moved from Chapter 26 in the 2017 edition to Section 21.8 in this edition.

All work must meet the latest NESC requirements; in particular, Rules 350 to 354 of Section 35. The current NESC is the 2023 Edition. Local State regulations issued by the State Public Utility Commissions (PUCs) or Public Service Commissions (PSC) may vary from the NESC.

A National One-Call “811” number is operable in all States to facilitate contact with State One-Call notification systems. The “One-Call Center” and/or a local utility location and coordination committee that is active in your area must be notified of scheduled construction activities no less than 48 hours before a subsurface operation.

**Note:** Based on State damage prevention, laws may require more than 48 hour notice. This should be verified in the planning stages of the job.

The “One-Call Center” will notify other subsurface facility operators to locate and mark their plant in the vicinity of the route before construction. For program details and contact information, go to [www.call811.com](http://www.call811.com) and/or the Common Ground Alliance (CGA) web site at <https://commongroundalliance.com>. See Chapter 2 for guidance and precautions for excavation and general work activities in buried plant facilities (in particular, see Sections 2.8 through 2.10).

### 21.1 Construction of Facilities - General

Buried plant is generally located along roads or highways, on public or private rights-of-way, along or near property lines, or in the space between the curb and the sidewalk. Buried service cables and wires will generally extend from closures across the premises of the subscriber to the designated facility to be served.

For public safety and protection of communications company buried plant, extra care and consideration should be given to the location of communications company facilities to minimize subsequent disturbance. Along roadways the plant should, when possible, be placed to avoid future construction activities (e.g., widening and surfacing operations). Special consideration should be given when selecting a route so as not to interfere with the natural land drainage; nor should the drainage impede upon the

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depth of soil coverage of the buried plant facilities.

When possible, points where the cable must be fed through pipes, conduits, or under obstacles should be located near splice points. The location for the plant should be selected so that it will take as direct a route as practical, without excessive damage to the roots of trees, shrubs, or other vegetation along the route. The route should be designed to avoid areas likely to be subjected to future excavation activities that might subject the plant to mechanical damage. Coordination with developers, local governments, contractors, and other utilities will help minimize the risk of such damage.

**Note:** The Occupational Safety and Health Administration (OSHA), *Construction Standards for Excavation*, regulates all excavations, including trenches.

Alternate installation methods should be considered where conventional open-cut trenching techniques are impractical or limited. Trenchless installation methods (e.g., directional drilling) may prove more feasible in congested areas and require less restoration.

Where practical, all common trenches shall be backfilled the same day the facilities of all the parties are placed in such trenches. Work associated with the placement of conduit under streets, and pipe-pushing or augering required in connection with common trenches, must be completed before any facilities are placed in such associated common trenches.

Each party shall coordinate the placing and connecting of its facilities in a common trench so as not to delay the similar requirements of any other party placing facilities in the same trench. Where conduit is required for any reason in a joint-buried distribution system, each party shall be responsible for providing its own duct(s) or conduit assembly.

As noted in [Section 21.2.4](#), the bonds of all parties occupying a common trench shall be interconnected. When such bonds are not interconnected at the time facilities are initially placed in a common trench, a No. 6 AWG copper bond wire shall be attached to the metallic sheath or shield and shall be long enough to reach the nearest transformer or other predetermined bonding point. Procedures for connecting such bonds shall be as specified in the applicable Buried Agreement, JUA, or ROW Agreement.

The facilities of any occupant of a common trench shall not be wrapped around the facilities of any other occupant of the trench.

## 21.2 Construction Specifications

The burial depths noted below are **minimum** safety depths based on issues discussed in Sections [2.8](#) through [2.10](#) and the NESC Rules 351 through 354 that are primarily based on:

- Electrical voltage/amperage risks associated from being in near proximity of energized electric supply cables, and

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- Providing sufficient working and access room for a worker to enable them to work efficiently and safely.

Since these are minimum depths, greater depth should always be used if practical to reduce the risk of trouble due to accidental dig-ups and, in particular, if it is known that future construction or excavation work is planned for the area. If possible, all communications drops should be placed at 18 inches or below. For example, planting a rose bush can easily cause surface disturbance to a depth of 12 inches.

Some local codes and state governmental authorities have required utility plants to maintain deeper burial depths than specified herein.

### 21.2.1 Random Separation of Communications Cables

When communications cables of two or more parties are buried at random separation in a trench not containing power facilities, bonding is not required. See [Table 21-1](#) for cable depths.

**Table 21-1 Cable Depth - Random Separation of Communications Cables [Note 1]**

| Facility                   | Depth of Cover Normal - Note [2] |        |
|----------------------------|----------------------------------|--------|
|                            | Fiber                            | Copper |
| Toll, trunk cable          | 30                               | 30     |
| Feeder, distribution cable | 24                               | 24     |
| Service wire               | 18                               | 12     |

**Note [1]** Additional requirements for random separation of power cables and communications cables in the same trench are covered in NESC Rule 354C. Communications cables are permitted to be buried with power cables in random separation up to 20 kV to ground. Over 20 kV requires a 1-foot separation between communications cable and power cable.

**Note [2]** Minimum required depth is listed. Greater depth will reduce the risk of trouble owing to dig ups and must be provided wherever future digging is likely to occur. Trench depth is governed by the NESC (Rule 352D) requirements for power cables, as shown in [Table 21-2](#).

**Table 21-2 Trench Depth**

| <b>Maximum Voltage to Ground (V)</b> | <b>Depth of Cover</b> |
|--------------------------------------|-----------------------|
| 0 to 600                             | 24 inches             |
| 601 to 50,000                        | 30 inches             |
| 50,001 and above                     | 42 inches             |

The buried plant should be installed so that the minimum depth of cover as shown in [Table 21-1](#) will be obtained. In some cases, however, additional cover is necessitated by other factors. Some of these conditions are, but may not be limited to, the following:

- In cropland and pastures, a cable depth of 36 inches is the minimum. Where subsoil plowing is done, the cable should be located at least 12 inches below the maximum depth attained by such agricultural equipment.
- When crossing railroads, highways, and streets, the depth of the plant should be sufficient to minimize the possibility of mechanical damage due to road grading or ditching activities and the usual maintenance work along the highway or railroad ROW.
  - When making a railroad crossing, the facility shall be at least 60 inches below the top of the rails.
  - Access points such as manholes and handholes should be located well back from rails and trackbed. The preference is to place such access points on the remote (as far as practical) edge of the utility right-of-way or easement.
- When working on rough or unfinished grade levels, the trench depth should be sufficient to meet minimum depth requirements at final grade level.

All installations shall conform to the appropriate codes. State and local laws may be more restrictive than the recommendations of this practice. Be aware of possible future activities that would be reasonably expected to disturb underground/buried plant, e.g., future development, construction, or excavation work planned for the area.

#### **21.2.1.1 Random Separation of Communications and Power Cables**

Supply cables or conductors and communications cables or conductors may be buried together at the same depth with no deliberate separation between facilities, if all parties involved agree and if all the following applicable requirements, derived from NESC Section 35 (Rules 350 to 354), are met:

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## 1. Voltage

- Grounded supply systems shall not be operated above 22,000 V phase-to-ground.
- Ungrounded supply systems shall not be operated above 5,300 V phase-to-phase.
- Cables of an ungrounded supply system operating above 300 V shall be of a design that includes a grounded concentric shield component. Such cables shall be maintained in close proximity to each other.
- Ungrounded supply circuits operating above 300 V between conductors and in random separation with communications conductors shall be equipped with a ground-fault indication system.
- Communications cables and communications service wire having metallic conductors or metallic components shall have a continuous metallic shield under the outer jacket.

**Note:** This requirement does not apply when it is only communications cables being jointly buried (reference Rule 354C of NESC).

- Communications protective devices shall be adequate for the voltage and currents expected to be impressed or induced on them in the event of contact with the supply conductors.
- In the vicinity of supply stations where large ground currents may flow, the effect of these currents on communications circuits should be evaluated before communications cables are placed in random separation with supply cables. For such locations, it is preferred that optical fiber cables be used for communications, and random separation placement configurations be avoided if at all possible.

## 2. Bare or Jacketed Grounded Conductor

- Except as permitted by NESC Rule 354D2, a supply facility operating above 300 V to ground shall include a bare or semi-conducting jacketed grounded conductor in continuous contact with the earth. This conductor, adequate for the expected magnitude and duration of the fault current that may be imposed, shall be one of the following:
  - A sheath, an insulation shield, or both.
  - Multiple concentric conductors closely spaced circumstantially.
  - A separate conductor in contact with the earth and in close proximity to the cable, where such cable or cables also have a grounded sheath or shield not necessarily in contact with the earth. The sheath, shield, or both, as well as the separate conductor, shall be adequate for the expected magnitude and duration of the fault currents that may be imposed.

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**Note:** This is applicable when a cable in a nonmetallic duct is considered as a direct-buried cable installation and random separation is desired.

**EXCEPTION:** Where buried cable passes through a short section of conduit such as under a roadway, the contact with earth of the grounded conductor can be omitted, provided the grounded conductor is continuous through the conduit.

- The bare conductor or conductors in contact with the earth shall be of suitable corrosion-resistant material. The conductor covered by a semi-conducting jacket shall be compatible with the jacketing compound.

**Note:** For many geographic areas, experience has shown that bare concentric copper neutral conductors experience severe corrosion.

- The radial resistivity of the semi-conducting jacket shall not be more than 100 meter ohms and shall remain essentially stable in service. The radial

resistivity of the jacket material is that value, calculated from measurements on a unit length of cable, of the resistance between the concentric neutral and a surrounding conducting medium. Radial resistivity is equal to the resistance of a unit length times the surface area of the jacket divided by the average thickness of the jacket over the neutral conductors. All dimensions are to be expressed in meters.

### 3. Insulating Jacketed Grounded Conductor

Each phase conductor of a multiple grounded supply system operating above 300 V to ground and having an overall insulating jacket shall have a grounded copper concentric conductor meeting all of the following requirements:

- Be adequate for the expected magnitude and duration of fault current that may be imposed –

**Note:** A requirement for the grounded conductor to “*have a conductance not less than one half that of the phase conductor*” was relaxed in the 2017 NESC providing that an analysis is completed to ensure that the protection circuits for the power facility are designed to meet the expected magnitude and duration of fault current that may be imposed on the system. Without such analysis, the grounded conductor of the circuit should be not less than one half that of the phase conductor.

- Be grounded in accordance with NESC Rule 314, except that the grounding interval required by NESC Rule 96C shall not be less than 8 grounds in each mile of the random buried section, not including grounds at individual services (applies to power-company cable only).

### 4. Insulating Jacket Grounded Neutral Supply Cables in Nonmetallic Duct

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If the power cables are insulating jacketed grounded neutral supply cables meeting the rules of 354D3 (see item #3 above) and installed in nonmetallic duct, then they may be randomly laid with communications cables.

The above requirements (items #1-to-4) parallel the relevant parts of NESC Rules 354D(1) through 354D(4).

Communications cables with FMPS (Fault Managed Power Systems) circuits meeting the criteria within ATIS Technical Report 600040 - *Fault Managed Power Distribution Technologies - Human Contact Fault* can be safely deployed without the need for a cable shield.

### 21.2.2 Planned Separation of Cables

If and where the provisions of [Section 21.2.2](#) are not met, a 1-foot separation, or more, is required between communications and power cables. Where the planned separation between communications and power cables exceeds 3 feet, bonding and grounding provisions shall be as mutually agreed upon.

All above-ground communications terminals, apparatus cases, and cable closures shall be bonded at any above-ground power apparatus located within 6 feet of such communications facilities.

**Note:** A revision introduced in the NESC 2007 Edition to Rule 384C, included the following language: *“For the purpose of this rule, pole grounds are not considered an above-ground metallic power apparatus and therefore not required to be bonded to the communications apparatus.”*

**Note:** A revision added to the 2017 Edition of the NESC added a clarifying informational note to Rule 384C to state *“This rule does not prohibit bonding communications metallic enclosures to supply pole grounds, providing all affected parties are in agreement.”*

If permitted by the supply company, Ericsson - NIS recommends that, for increased safety, a bond be made between an MGN pole ground and an adjacent pedestal within 6 feet of the pole. The NESC Rule 384C language<sup>4</sup> was not intended to prohibit such a bonding connection, as evidenced by the new information note added to the 2017 Edition. Ericsson - NIS does recognize that there are situations where bonding to the vertical pole ground of the power company may not be recommended or desirable because, for example:

- a. The pole ground is not an MGN, but a dedicated ground for a lightning arrestor, or
- b. Significant current may appear on that ground during a power fault condition, or
- c. A bond to a power ground from a single point system (i.e., Delta system) may place undesirable current into the communications equipment during power fault or lightning incident.

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Further discussions on the purposes of bonding and grounding and the relevant rules in the NESC can be found in Chapters 10 and 25 in general, specifically in Sections 10.1, 10.2, 10.5, 25.1 and 25.2.

It is undesirable for the communications facilities or equipment to become the preferred low resistance/impedance path to ground for fault or lightning current, not only because of possible damage to the communications equipment, but also because it may interfere with the operation of the protection devices and schemes for the power supply circuits.

If permission to bond to the MGN is denied by the power company or pole owner, then contact the Inductive Coordination and Electrical Protection (ICEP) engineer. In such circumstances, a communications company may wish to consider placing a dedicated communications ground bed similar to that described in [Section 10.5](#) consisting of a series of interconnected driven ground rods bonded to the communications plant for the safety of workers and/or to help maintain the reliability of equipment and the quality of the communications services.

### 21.2.3 Bonding and Grounding

When communications and power cables are buried in a common trench, bonding and grounding shall be provided as follows:

- All grounds shall be interconnected at each transformer location unless other arrangements have been made with the power company. These grounds include the continuously grounded primary neutral and/or grounding conductor, secondary and service neutrals, supply cable shield or sheath, communications cable shields or sheaths, and equipment grounds.
- All communications metallic cable sheaths and/or wire shields and secondary neutrals shall be connected to a common ground at all customer service entrances.
- Bonds shall be made directly to the ground supply apparatus at all above-ground communications terminals, apparatus cases, and cable closures located within 6 feet of any above-ground supply apparatus (see further information in [Section 21.2.3](#)).
- If spacing between transformer locations is less than 1,000 feet, bonding at each transformer location is sufficient. If the spacing between transformer locations is 1,000 feet or more, additional bonds must be made so that bond points are not more than 1,000 feet apart (4 per mile).
  - NESC Rule 096 was modified in 2017 to allow exceptions to the 4 grounds in every mile rule for long uninterrupted spans such as those that occur when lines cross valleys and under waterways. These long runs (spans) of cable that occur without any splice point make access very limited or impossible. Correlating changes were made in Rules 342 and 354D to provide an effective ground at the

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first opportunity on either side of such a long span.

- Bonding between communications closures may be omitted at any closure or transformer if the distance to each adjacent bond point is less than 500 feet. However, a bond must be made at least at every other closure.

#### **21.2.4 Bonding and Grounding of Buried Optical Fiber Cable**

Further discussions on bonding and grounding aspects for optical fiber cables can be found in Chapters 25 and 10 in general, and Section 25.3.4 in particular.

- Optical fiber cables having metallic components, including metallic shields, are susceptible to inductive pickup from unbalanced currents in nearby aerial or underground power lines. If of sufficient length, significant voltages can be induced on the shields.
- Appropriate grounding intervals will reduce voltages to a safe level if a cable were cut or intentionally opened by a craftsperson for reconfiguration or maintenance.
- For various reasons, shields must not be floated. The discontinuities in the shield can result in lightning-related arcs occurring within components and the low impedance to ground will not be high enough to limit current to acceptable values.
- Fiber cables constructed with double metallic shields must always be bonded together at discrete intervals. In long lengths of cable, significant voltages between two un-bonded shields can develop.
- Grounds must be installed at all splice and regenerator locations. It is recommended that power company multi-grounded neutrals be avoided as a ground point. While this provides a low impedance ground, it also permits high fault currents to enter the communications plant. In some cases, these currents can overheat and damage optical cable. Since these long haul fiber cables can run for many miles with no splice or regenerator, there is a possible risk of introducing a power fault through an MGN connection that may travel a long way along the cable and cause damage.
- The following procedure must be followed when entering an intact cable (i.e., a cable with an unbroken sheath/jacket) unless it is known that installed grounding provisions have limited the voltages to safe levels:
  - While wearing insulating gloves, expose the metallic component and test with a voltage tester.
  - If an unsatisfactory high voltage is detected, correct the condition.
  - If the voltage is at a safe level, place a temporary bond across the opening and perform the necessary work without the insulating gloves.

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- Maintain a temporary bond for the duration of the job and until the permanent bond has been reestablished.
- The following procedure is recommended for repairing cables:
  - Proceed as above to measure voltage at the metallic component. If acceptable voltages are not exceeded, install a temporary bond. Gloves need not be worn.
  - If an unsatisfactory voltage level is detected, install the bond while wearing gloves and recheck the voltage at both sides of the open.
  - If an unsatisfactory voltage persists, check the integrity of the bond and correct the condition, as required.
  - When safe voltages are obtained, the gloves may be removed. Maintain a temporary bond for the duration of the job and until the permanent bond has been reestablished.

### 21.2.5 Conduit Size

The choice of conduit type and size for underground and buried facilities is often determined not only by the expected compression loads, installation properties, and long-term functional performance issues, but also by the relative costs (material and installation costs) for the various conduit size and types.

For direct-buried applications, the key functional performance issues for the conduit choice include:

- Compression and vibrational loadings expected from the surface activity in the area
  - Traffic loads and frequencies under the highway, road or driveways require substantial cover to be provided for buried plant. For example, under a typical roadway one may need 36 inches of cover consisting of soil, rock and roadbed above the conduit or cable.
  - Pedestrian or customer activities under sidewalks or in the private property of the customer (e.g., gardening, landscaping, erection of sheds, swimming pools, garages, and so forth).
- Installation may require even greater depths when one needs to avoid existing plant or other utilities as well as obstacles such as subways, storage and septic tanks.
- Intrinsic tensile and compression strength of conduit material required to withstand
  - The compression loads such as noted above, and
  - The installation forces that occur during excavation work, and pull-back operations during direct-drilling procedures (see [Chapter 24](#))

- Design allowances for
  - The appropriate design safety factor (usually at least 2 for conduits in direct buried applications) applied to the necessary conduit strength
  - Long-term effects of the possible operating conditions (e.g., hot/cold temperatures, direct sunlight exposure) and long-term deformation (creep) over time.
- Installation method choices can permit the use of less robust conduit for an application, and additional protection or cushioning is provided by using
  - Added sand or other cushioning material to provide better surroundings (smoother to distribute load more evenly across the conduit) around the conduit than pebbles, rocky soil or other backfill materials that could mechanically damage the conduit
  - Physical barriers between the surface and conduit to help distribute loads from traffic or activity and thereby lower any forces on the conduit.

The current Ericsson - NIS reference documents that provide functional performance requirements and application guidance for these conduits are GR-356 and GR-3155. Recommended sizes and pulling strengths from these industry standards are provided in Tables 21-3 and 21-4.

**Table 21-3 Conduit/Innerduct Selection Guide**

| Type of Installation     | Suggested SDR Designation |
|--------------------------|---------------------------|
| Direct-Buried            | SDR 11                    |
| Underground (in conduit) | SDR 13.5                  |
| Aerial                   | SDR 13.5                  |
| Building                 | SDR 13.5                  |
| Buried Service Wire      | SDR 11                    |

**Table 21-4 Conduit/Innerduct - Minimum Working Pulling Strength (\*)**

| Innerduct Nominal Size | SDR 11   | SDR 13.5 |
|------------------------|----------|----------|
| 1-1/4 inch             | 1500 lbf | 1100 lbf |
| 2 inch                 | 4500 lbf | 3600 lbf |

(\*) Pull strengths noted in pounds-force (lbf) are based on ASTM D3035 material specification.

The general industry standard for direct-buried conduit/duct is SDR 11 with the less robust, thinner-wall SDR 13.5 conduit size used for the duct (innerduct) that is placed inside another conduit that provides the primary protection. For deployments involving significant tensile or flexural stress on ducts, such as in directional drilling methods (see [Chapter 24](#)), the more robust SDR 11 product is preferred to maximize the span lengths that can be placed in a single operation.

### 21.2.5.1 Microduct Choices

Single and bundled microduct products are being more widely used for optical fiber applications to deploy small optical fiber cables and jumpers inside customer premises, service drops and for short distance spans linking facilities. These facilities include direct-buried applications and microtrenching deployments that are discussed more fully in [Section 27.2.7](#), “Microducts and Fabric Sleeves,” and [Section 23.5](#), “Microtrenching in Urban Environments.”

The choice of which microduct to use for a given application is explored in GR-3155 and the above referenced sections. However, as a general principle for optical fiber cables placed in microduct for direct-buried applications, additional physical protection and warning tapes are highly desirable for such uses to help minimize damage during excavation by other utilities and persons in the area.

### 21.2.6 Depth of Buried Cable

All power cables operating at between 601 V and 50,000 V and buried at random separation with communications cables shall be at a minimum depth of 32 inches with a 30-inch cover, as required by the NESC Table 352-1 for power conductors, except under the following conditions:

- Where power cables operate at less than 601 V, facilities may be buried at a minimum depth of 25 inches with a 24-inch cover.
- Where shale or rocky soil is encountered, the minimum depth shall be increased by 3 inches to permit placement of clean fill in the bottom of the trench.
- Where dense rock formation is encountered, the minimum depth may be reduced to 25 inches.
- Where suitable mechanical protection is provided, the minimum depth may be less than 24 inches.

There is an allowance for lighting cables (serving street lights) operating at less than 150 V to ground to be buried with a minimum of only 18 inches of cover.

As part of the location process (One-Call 811 service), the depth of the buried plant that is being located should be provided.



### 21.2.7 Trench Bottom and Backfill

The trench bottom should be relatively smooth, undisturbed earth that is well-tamped, or sand. This is particularly important when placing buried innerduct. When excavation is in rock or rocky soils, the cable should be laid on a protective layer of well-tamped backfill. Backfill within 6 inches of the cable should be free of materials that may damage the cable. Backfill should be adequately compacted. Machine compaction should not be used within 6 inches of the cable. When communications plant must pass under shrubs, sidewalks, paved streets, etc., it may be advantageous to push or drive a length of pipe or conduit under such obstacles instead of opening a trench. Directional drilling, rod pushers, or pneumatic moles may provide a convenient and practical alternative method of installation in some cases.

Where possible, colored warning tapes identifying the cables as communications cables shall be placed 12 inches above cables.

### 21.2.8 Soil and Dust Management

During excavation for a trench or a handhole, soil and dust can be raised that may need to be controlled and managed as well as response to leaks and spills. For instance, there are naturally occurring asbestos in some soils (e.g., California) that requires containment. Typical precautions to protect workers and the environment can include:

- Spill/Leak Prevention – Have readily available sufficient oil and grease absorbing materials to contain and clean-up for fuel or chemical spills or leaks.
- Dust Control – Water the ground every 2-3 hours to prevent dust generation from dry ground. Do not over saturate the soil so much that run-off causes pooling or erosion.
- Wet-sweeping or Vacuuming – If necessary to minimize airborne dust, sweep or vacuum 2-3 times per day (more often if needed) streets, sidewalks and intersection around the work area to prevent material (dust) from spreading into adjacent areas. For efficiency, the vacuum should use a HEPA (High Efficiency Particulate Air) Filter.
- Control of Dust – Dust enclosures, curtains and dust collectors may be necessary to control or limit dust generation and migration.
- Dirt & Mud Removal – For extensive work areas, gravel driveways can be used at work sites to reduce the spread of dirt and mud.



### 21.2.9 Trouble and Maintenance Procedures

When it becomes necessary to excavate for repairs, maintenance, or extensions to existing facilities, the following procedures and precautions shall be followed:

- When any party must expose its facilities for repair, maintenance, or extension purposes, the party shall, prior to digging, notify all other occupants of the trench. Each occupant may choose to have representatives present to protect its facilities from damage during the period in which repairs are being made.
- Power digging equipment shall not be used within 24 inches of buried facilities. It shall be the responsibility of the party doing the digging to locate and expose by hand-digging the facilities of all occupants of the trench. Hand-digging tools shall have handles of wood, fiberglass or a material of comparable insulation value. Digging bars will not be used in the vicinity of buried cables.
- The physical appearance of some communications and power cables is so similar that visual identification is often difficult. Cables should have embossed printing as per NESC Rule 350F (Figure 350-1) to help provide positive identification; however, the printing may not be easily discernible or legible after burial. Employees of all parties whose facilities occupy a common trench shall therefore make positive identification of their cables before cutting or opening the sheath, unless the identity is obvious by reason of physical appearance.
- Where both communications and power facilities are in trouble, representatives of all occupants must be present when repairs are made.
- In case of maintenance operations not involving trouble of any of the parties involved, parties may proceed to dig and perform the necessary maintenance, subject to the rules and limitations set forth in other requirements of this section, without having a representative of the other party or parties present.

**! CAUTION !** Communications company representatives may not move or handle any energized power cables as a general rule. Where communications and primary power cables are buried at random separation, communications company employees may, using rubber gloves and eye protection, move communications cables to obtain needed separation to work on its cables. If separation cannot be obtained, the power company will be requested to move its cable.

### 21.2.10 Joint-Use Buried Networks - Buried Duct Networks (BDNs)

As communications and power service demands increase and newer optical fiber-based communications technologies develop, the need to add new service cables is not infrequent. BDN systems are intended to represent a cost-effective, space-efficient overall solution for direct-buried placement of multiple utilities (e.g., electric power, telephone, and CATV), e.g., where communications and power cables in separate conduits share a common trench and handhole access points.

The BDN network would consist of a rigid or semi-rigid conduit for the main conduit runs and flexible duct or innerduct for the lateral feeds from/to adjacent terminals, external to the common handholes for the service drops or multiple customer feeds. The main conduit runs need to resist compression forces of being buried up to 36-40 inches deep and, depending upon the method of installation, have sufficient tensile strength to survive installation forces associated with pulling ducts into place using Horizontal Directional Drilling (HDD). See [Chapter 24](#).

The BDN handholes are required to be of sufficient strength and have sufficient working space within the BDN handhole for a technician to (a) access the main conduit and the cables contained therein, and (b) be able to feed the distribution cable or cable-in-duct laterally through the wall openings without kinking the cable or causing abrasion damage or mechanical damage to the cable sheath and components of the cable core. BDN handholes are expected to meet industry standards such as GR-902-CORE, *Generic Requirements for Handholes and Other Below-Ground Splice Vaults*.

The current uses of a BDN network excludes splice points/connections being placed inside the main BDN handhole. However, the future uses and applications may include splices or even equipment inside these BDN handholes, and this will require sufficient working space to prepare splices and connect equipment.

BDN networks do require additional up-front planning and additional materials compared to the direct-buried approach. However, the BDN approach provides the valuable benefit of a clear accessible pathway along a cable run, which can greatly reduce the future costs associated with the alternative approach of disturbing the ground or roadway for plant upgrades and additions. Utilities would include the future savings in upgrade construction costs when the implementation of a BDN approach is being considered.

Under current regulations, the builder/owner of a BDN network would find that they would be required to allow access to the empty conduits for competitors' cables if requested. The value of having empty conduits available for a future unspecified use is not recognized as such by companies or regulatory commissions. All network plants usually need to be used immediately or are considered abandoned plants. The effective and efficient use of BDN networks requires recognition of the value of deferred return-on-

investment and the full ownership rights of the BDN builder(s).

Different configurations such as multi-layer and parallel conduit systems will naturally arise as uses and applications expand for the BDN networks. In all circumstances, mutual cooperation and inter-company communications is needed between the partners to make the BDN network works expand. Cooperation between partner companies needs to be codified in JUAs and contracts.

Such new approaches to joint placement of communications and power are still relatively new; they require a customized set of construction guidelines, which is beyond the scope of this document. The joint placement of separate cables and the deployment of hybrid cables are two of the suggested means to provide power and communications to wireless antenna facilities on poles, towers and other structures. The separate cables can be housed in different, distinctive conduits, ducts, or microducts to obtain the desirable separation, clearance and protection. Hybrid or composite cables, with copper conductors for power plus optical fibers or coaxial cables for communications, will require customized methods and procedures for the technician to be trained in their use and maintenance.

**Note:** Also see Section 16.2.1 (*Power and Communications in Manhole/Handhole*) for discussions on a possible alternative approach with joint-use of a manhole for communications and power cables collocated in the same space.

### 21.3 Cable Placing

Cable should be carefully laid on the trench bottom, always observing the tension and bonding limitations of the cable prescribed by the manufacturer. As a general rule, copper conductor cables should not be bent to a radius less than 10 times their own cross-sectional diameter. This rule is also valid for optical fiber cable under no tensile load. However, under a load, optical fiber cable should not be bent to less than 15 times the cable diameter.

Always avoid using equipment that will cause abrasion to the cable sheath. Do not put a reverse bend in the cable during placement.

When installing cables for either distribution or drop services, the placement of spare vacant flexible innerduct will facilitate future facility upgrades to the plant. Permanent surface structures, roads and nearby utilities in the Rights-of-Way may prove to be large and costly obstacles to new construction. Flexible innerduct can provide an economical means to facilitate future service needs.

## 21.4 Splice Point Excavations

Splices should be made either in re-enterable splice enclosures or in an approved apparatus closure. Whatever the method selected, the splice must be supported on a firm foundation of well-compacted soil.

At each splice location, the excavation should be able to accommodate the splice closure or splice support. The excavation should be at least 6 inches deeper than the final depth of the splice. Fill the excavation with clean sand, gravel, or crushed stone to slightly above the final grade of the splice. Compact the fill by tamping to the final grade of the splice or splice support. If a re-enterable splice enclosure is used, place it in the final position.

Depending on the method of optical fiber splicing being employed, large amounts of cable slack may remain upon completion. If so, provisions must be made when excavating to accommodate the storage of this cable slack.

After the splice has been made, secure the splice case to the buried support or position it inside the splice enclosure. Fill the excavation with a fine gravel, pea gravel, or similar recommended filling compound.

On fiber cable routes, all buried splices should be marked with buried electronic markers, or follow approved procedures governed by local practices. Regardless of the method used, a test of the system should be made to ensure that it is functioning properly before backfilling begins.

## 21.5 Handholes

### 21.5.1 Applications

Handholes are plastic or concrete structures set below ground with their lids flush to the surrounding soil, turf, footpath or road surface. These enclosures are usually 12 to 36 inches deep, and can be used to:

- House and protect copper, coaxial, and optical fiber telephone cable splices
- Provide convenient access to, while safeguarding, cable termination and branch points
- Provide flexibility and access for installation operations (e.g., pulling or blowing cables).

These below-ground enclosures provide mechanical and environmental protection for the splices contained within, allow access for craftsperson work activities, and discourage access by unauthorized persons. By using appropriate color choices and the flush-to-grade designs available with handholes, aesthetic concerns associated with aerial plant, poles, and above-ground pedestals can be averted.

Field reports of broken and buckled sidewalls as well as collapsed and

warped lids have raised concerns about the structural integrity of these handholes. These failures have presumably been caused by vertical and/or lateral loads that were too large for the enclosure to withstand. Soil preparation and general installation methods and procedures may also have contributed to these field failures. Once the handhole is cracked or distorted, water will easily penetrate, and burrowing animals such as gophers, groundhogs, and squirrels can more easily enter the handhole and damage the facilities.

To avoid such field problems, handholes need to meet performance requirements appropriate for the deployment location, with specific attention given to the expected loading. See GR-902-CORE, *Generic Requirements for Handholes and Other Below-Ground Splice Vaults*, and GR-26-CORE, *Generic Requirements for Controlled Environmental Vaults (CEVs)* for guidance on functional performance criteria.

The major distinctions in these applications environments focus on the strength and frequency of vehicular and foot traffic loading. There are four basic application zones for handholes or below-ground vaults; they are listed below in order of decreasing loading levels. The design strength and materials requirements for such structures can be found in GR-902.

1. **Category IV = Heavy-Duty Zone or Continuous and Heavy Traffic Zone:** For applications of heavy continuous traffic, below-ground enclosures need to be constructed from very strong, rigid materials such as precast concrete. Such handholes and application environments fall under the same class as concrete manholes and CEVs, which are discussed in the underground sections of this [Blue Book](#) (see Chapters 16 through 20). These areas are subject to traffic up to and including tractor-trailer trucks (Class 8)<sup>7</sup>. These installations generally benefit from a concrete collar (surround) for the handhole or manhole.

**Note:** The strength of concrete structures such as manholes and CEVs are designed to meet AASHTO H-20 loadings for continuous traffic, and appropriate design criteria can be found in GR-902 and in Section 3.1 of Ericsson - NIS GR-26. Materials criteria for the structural concrete/cement walls and reinforcing steel rods can be found in Section 3.2 of GR-26.

2. **Category III = Heavy Duty Zone or Non-Deliberate Vehicular Traffic Zone:** A non-deliberate vehicular traffic environment is an area where there is light truck and car traffic traveling the roads at sporadic times of the day. An example of a non-continuous vehicular traffic area is a secondary street or side road. Large tractor trailers are not allowed on these roads, but there is still significant vehicular traffic. These are areas with non-deliberate vehicular traffic limited to Class 7 vehicles (e.g., 2-1/2-ton truck). This zone would include a handhole (vault) that has a cabinet or pedestal installed on top of a Polymer Concrete (PC) cover.

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3. **Category II = Medium Duty Zone or Pedestrian and Light Incidental Traffic Only Zone:** A pedestrian/light incidental traffic zone is an area off the main road with frequent pedestrian traffic and the occasional car or truck pulling up over the handhole for a variety of reasons (e.g., a truck may pull up to fix a streetlight or trim trees). An example of a pedestrian/light incidental traffic area is the ground along a sidewalk or walkway. These are areas with pedestrian traffic and non-deliberate vehicular traffic limited to Class 5 vehicles (e.g., 1-1/2- ton truck).
4. **Category I = Light Duty Zones or Greenway Zones:** Greenways are areas with minimal pedestrian traffic and no vehicular traffic. These zones could include parkland and peripheral areas on golf courses where no traffic passes and no regular pedestrians are found. The closures may be stepped on by animals (e.g., deer) or an occasional hiker or bicyclist. It is assumed that the closure is located away from areas where tractors, trucks, automobiles, or agricultural machinery are found. Closures for such greenways are assumed to be small, i.e., no more than 18 inches in height.

**Note:** GR-902 is not intended to cover manholes or handholes that are installed as a traffic rated product with continuous Heavy Duty Vehicular Traffic, e.g., a roadway. The difference between Category IV and a roadway is that Category IV has Heavy Duty Incidental and Non-Deliberate Vehicular Traffic, and a roadway has Continuous and Deliberate Heavy Duty Vehicular Traffic with products rated at H-20.

**Note:** For the zone descriptions and discussions above, the following definitions apply to traffic:

- Incidental – Occurs by chance.
- Expected – Probable occurrence.
- Deliberate – Intentional, considered and with forethought. Examples would include traffic lanes in alleyways, roads, streets and highways, bridges, as well as entrances to parking lots/garages, loading docks, truck terminals, gas stations, and around garbage dumpsters. Individual decisions on shoulders of roads may be required depending on the probability and likelihood of traffic leaving the traffic lanes for parking or emergency stops.
- Non-deliberate – Not intentional, occurring by accident. Examples include sidewalks, parks, playgrounds, grassy areas, behind curbs, immediately adjacent to light poles, and residential yards.

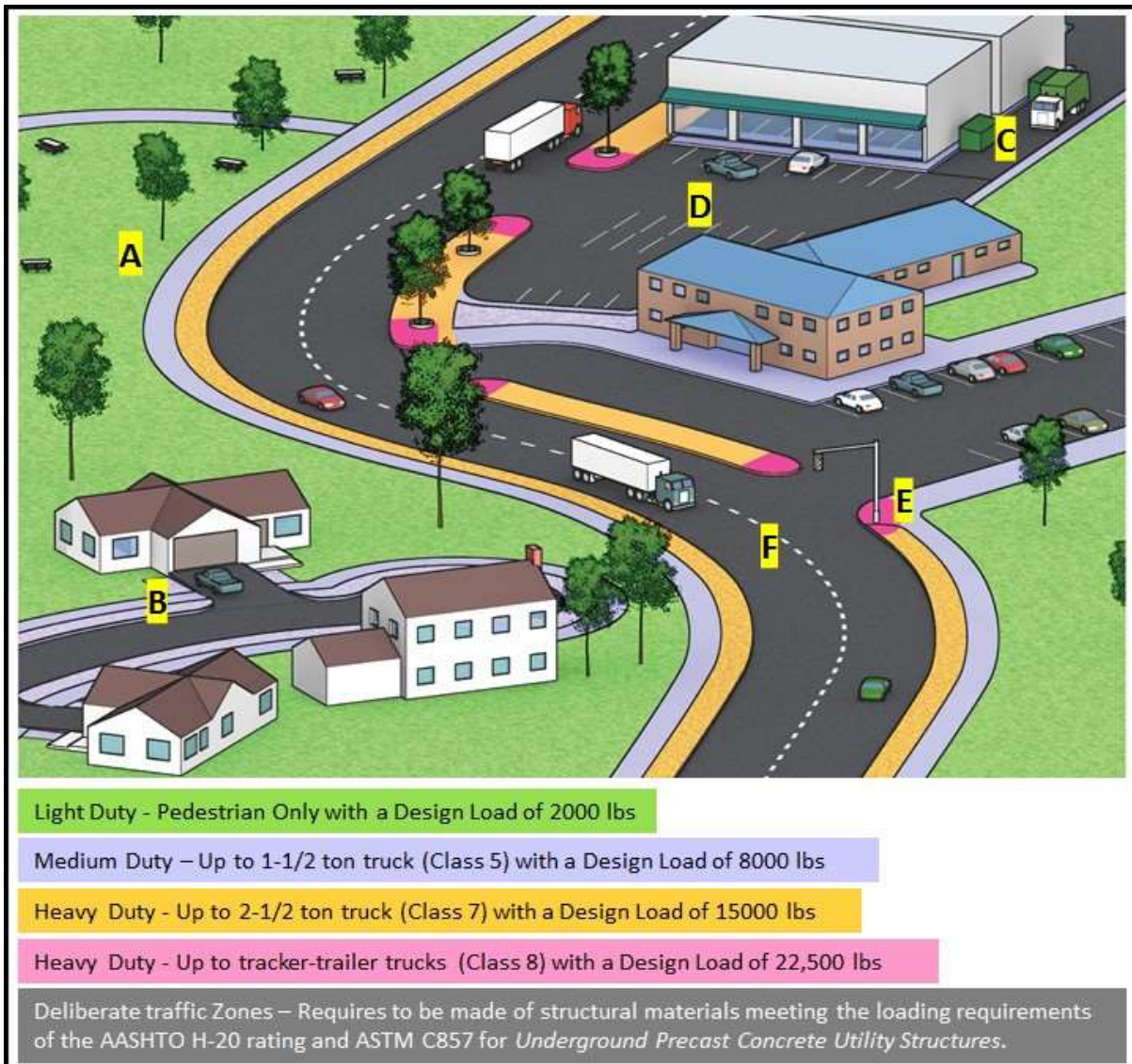
When handholes are mentioned in reference to communications buried plant, the three lower loading applications (Zones 2, 3, and 4 in the above list) are the products usually being referenced in GR-902. [Figure 21-1](#) shows the colored-coded application guide from GR-902 for handholes placed in these non-deliberate traffic locations. Although the handholes listed in the Category IV - Heavy Duty zone (Zone 1 in the above list) are included in



GR-902 and the application guide, vaults for these areas will usually be the traditional concrete manholes, as discussed in Chapters 16- 20 of this *Blue Book*, that are designed for deliberate and regular truck traffic.

The product selection of a handhole begins with meeting the functional performance requirements of GR-902, and is then coupled with the proper placement and installation of the handhole for the construction of a reliable and robust outside plant route. There is considerable application guidance found in GR- 902, including *Figure 21-1* shown below, illustrating the zones for a typical urban environment.

**Figure 21-1 Handhole Application Guide from GR-902**



To illustrate examples of handhole placement, we can consider several areas in [Figure 21-1](#) denoted with yellow highlighted letters (A through F).

- A. **Grassy Areas and Median Strips Off Divided Highways** – Light-duty rated handholes are suitable for grassy parklands and for median strips and sidewalks along streets and areas where deliberate traffic is not expected.
- B. **Secondary Roads and Suburban/Residential Areas** – Light- and medium- duty rated closures can be placed in grassy lawns and garden areas or sidewalks. They may also be placed in areas next to structures such as letter boxes and ornamental garden sculptures where it is unlikely a vehicle will run over the enclosure. The light- and medium-duty closures should not be placed in the street or driveway where deliberate traffic is likely and anticipated.
- C. **Alley Ways** are expected to have deliberate truck traffic with heavy garbage trucks and other delivery trucks up to and including tractor-trailers. The travel lanes in these zones will generally require manhole cast concrete type structures meeting the AASHTO H-20 rated vaults. Even though the traffic expected on the concrete apron or in front of the receptacle is occasional, it is deliberate because the traffic is both intentional and heavy duty in nature. In the adjacent areas to where a trash receptacle is placed, and in areas from where the truck approaches, a heavy duty (Category III) handhole closure can be placed away from the concrete that the receptacle is set on so that the receptacle will not be placed on the closure.
- D. **Parking Lots** – Although the majority of the parking area needs to have the cast concrete type structures meeting the AASHTO H-20 rated vaults, there are locations where medium-duty or heavy-duty (Category III) handholes can be used safely:
  - In the front center of a parking space with a heavy-duty (Category III) closure placed so that the tires of the vehicle will straddle the enclosure.
  - In the grassy area where the parking lot ends, a medium-duty or heavy-duty (Category III) handhole is sufficient.
  - Heavy-duty rated handholes can be placed alongside and close to the lighting pole since vehicles should not be expected to be located there.
  - Medium-duty or heavy-duty rated handholes may be placed between the parking curbs where the possibility of a vehicle running over the enclosure is remote. This closure could be placed anywhere between the parking curbs.
- E. **Corners Adjacent to Highways, Roads, and Other Areas with Deliberate Traffic** – A medium-duty rated closure can be placed in any grassy area, and a heavy-duty one can be placed in most sidewalks. However, a handhole closure should not be placed in a sidewalk where a driveway



crosses over the sidewalk. The paved shoulder of the highway is normally considered a deliberate traffic location because it may be used as a breakdown lane or as a lane in heavy traffic periods or in times of construction. Therefore, a handhole should never be placed in the paved shoulder of a road or in the road itself. The handhole, if required, should be placed off the shoulder, in the grassy area. The areas around corners where trucks and other vehicles may be anticipated to be zones where incidental non-deliberate traffic may transverse (by accident); therefore, they may require the use of heavy-duty rated handholes or AASHTO H-20 rated concrete vaults if the probability of trucks rolling over the closure is significant.

- F. **Roads and Divided Highways with Deliberate Traffic** – Vaults for these areas will usually be required to be the traditional concrete manholes, as discussed in Chapters 16-20 of this *Blue Book*, that are designed for deliberate and regular truck traffic and are rated to AASHTO H-20 levels. The paved shoulder of the highway is normally considered a deliberate traffic location requiring that the highest rating for closures be used in the shoulders.

### 21.5.2 Installation

Enclosures should be strategically placed to accommodate splicing and/or future distribution points along the route. The proper placement of an enclosure and its contents is critical to the safety and protection of the OSP. The following are general guidelines to follow when placing splice enclosures and cables within the enclosures:

1. Before placement of cables, the splice enclosure site should be excavated to accommodate cable placement, in both directions.
2. Once the cables have been placed, enclosures need to be placed promptly to protect the cables.
3. If the placement depth of the cable is deeper than the depth of the enclosure, the cables must remain at that depth and enter the enclosure at approximately 90°. If a cable is to be placed within an innerduct, the duct should be configured to accommodate this 90° entry. Be sure to bring the duct sufficiently high into the enclosure cavity so that it is not buried during backfill.
4. Seal around the duct opening or cable before backfilling occurs.
5. Before placing an enclosure, backfill the excavated site with sand to a point  
2 inches below the grade level. This is to accommodate the entire depth of the enclosure, plus 2 inches.
6. Tamp the sand for firm footing and level ground. Use extra caution not to damage the cable and innerduct.

7. The next 2 inches of the excavation should be filled with pea gravel. The gravel is used to help reduce moisture. The gravel should also be tamped.
8. Now place the enclosure over the cable ends and sit it firmly on the ground.
9. Backfill around the enclosure with 2 or more inches of gravel and tamp. Fill the rest of the area around the enclosure with clean backfill (not rocks, gravel, or sand) and tamp down.

The proper design, installation, placement and maintenance of these handholes will become increasingly more critical as active and passive components of broadband and optical fiber networks are deployed in them. Many of these network elements are more complex and sensitive and, therefore, need reliable protection from water ingress and physical stress.

In addition, equipment placed in these handholes needs to be designed with the assumption of possible, if not probable, moisture or water penetration, along with unwanted animal activity that can damage the network elements. For example, the product designs and installation procedures for splice and joining products, terminal blocks and branch points need to include the options of secondary protection (e.g., encapsulation or airtight seals).

### 21.5.3 Bonding in Handholes

The handhole closures are usually open on the bottom with a 6-inch deep layer of gravel (pea gravel, #57 gravel or 3/4-inch aggregate) in the bottom. The location and placing of bonding connections shall be as noted in [Chapter 18](#) and [Section 21.2.4](#), with the exception for cables that are pulled through a handhole with no splices or opening of sheath. Handholes are often used for these pull-through (no splice) closures since they are often used in cable deployments by directional drilling methods (see [Chapter 24](#)).

Where necessary for effective grounding of the communications circuits and closures, a driven ground rod (see [Chapter 25](#) for a full discussion of grounding means) is usually placed near one corner of the handhole (e.g., ~6-8 inches from walls) prior to adding the gravel layer.

## 21.6 Backfilling and Ground Restoration

Backfilling may be done by machinery or by hand, depending on local conditions, economics, and the equipment available.

The trench and the space outside splicing enclosures should be backfilled as soon as practical.

Backfilling materials and practices shall conform to local regulations.

The first 6 inches of fill directly above the cable must be clean sand, crushed stone dust, or sandy soil. The fill should be free of rocks, pavement, and frozen material that might damage cable. A trench filled with select granular material will compact more readily than one filled with coarse or rocky material.

Where appropriate, such as on a private right-of-way, the earth should be mounded over to compensate for future settling. In such a case, arrangements should be scheduled to return in a specific period (e.g., 48 to 72 hours) to check that the ground has returned to a smooth contour (i.e., no residual mound or depression). The backfill of a trench may, in some cases, be satisfactorily packed down by running a crawler tractor or larger rubber-tired vehicle along the trench on top of the backfill. If the route is along a street or highway or in a location where piling the earth over the trench would be objectionable, the earth should be well tamped as it is placed in the trench. The best results will be obtained by making two passes with a machine tamper after each addition of 8 to 10 inches of backfill. As stated previously, machine compaction should not be used within 6 inches of the cable.

Where practical, the topsoil should be replaced at the top of the trench. In backfilling across lawns, the topsoil and sod should be carefully replaced unless other arrangements have been made with the property owner.

On hillsides and at other locations where there is a danger of washouts exposing the cable or wire, thorough and complete machine tamping will help prevent such washouts. In some locations, rip-rap or other means of holding the backfill should be placed as soon as the backfill is completed.

All permanent pavement and sidewalks must be restored to the satisfaction of the proper authorities. When backfilling is finished, thoroughly clean up the work area.

## **21.7 Permanent Markings**

For general protection and awareness of buried facilities, the use of permanent above-ground markers and/or underground warning tape is recommended. These warning devices indicate that underground facilities are in the general area. They do not, however, provide the precise location of buried plant.

The above-ground markers should indicate the name of the facility owner, as well as the telephone contact number to call for the exact location of the facility. These markers should be placed, when possible, within sight of one another, but not farther than 1,000 feet apart.

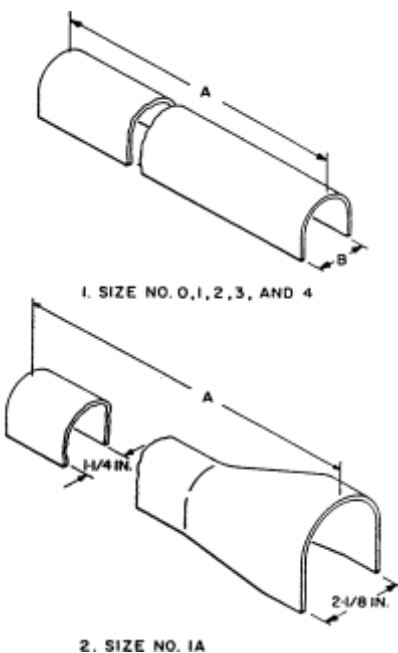
Warning tape should be buried 12 to 18 inches directly above the cable.

Although markers do not provide the precise location of buried facilities, they do add to the awareness of their existence, and enhance protection from unnecessary cable hits.

## 21.8 U-Type Cable Guards

U-type cable guards with cast iron or G plastic caps are used to provide mechanical protection for the cable that is placed in a communications company-owned conduit or licensee-owned conduit installed vertically on poles or run up building walls. See Figure 21-2 and Table 21-5 for guard sizes and attachment hardware. The relationship among conduit sizes, cast iron or G plastic caps, U cable guards, and cable sizes is shown in Table 21-6.

**Figure 21-2 Cable Guard**



**Note:** For A and B dimensions, see Table 21-5.

**Table 21-5 U Cable Guards, Straps, and Material Required for Installing U Cable Guards**

| Size No.      | Length A (Feet) | Inside Diameter B (Inch) | U Cable Guard Strap Size No. | Drive Screw for Use on Poles (Inch) | Hammer Drive Anchor for Use on Solid Masonry (Inch) | Toggle Bolts for Use on Hollow Masonry (Inch) |
|---------------|-----------------|--------------------------|------------------------------|-------------------------------------|-----------------------------------------------------|-----------------------------------------------|
| 0<br>[Note 1] | 5 or 8          | 3/4                      | 0                            | 1/4 x 2-1/2                         | 1/4 x 1                                             | 1/4 x 4                                       |
| 1<br>[Note 1] | 5 or 8          | 1-1/8                    | 1                            | 1/4 x 2-1/2                         | 1/4 x 1                                             | 1/4 x 4                                       |
| 1A            | 5 or 8          | 1-1/4                    | 1A                           | 1/4 x 2-1/2                         | 1/4 x 1-1/4                                         | 1/4 x 4                                       |
| 2             | 5 or 8          | 2-3/16                   | 2                            | 1/4 x 2-1/2                         | 1/4 x 1-1/4                                         | 1/4 x 4                                       |
| 3             | 5 or 8          | 3-3/16                   | 3                            | 5/16 x 3                            | 5/16 x 1-1/4                                        | 1/4 x 4                                       |
| 4             | 8               | 3-11/16                  | 4                            | 5/16 x 3                            | 5/16 x 1-1/4                                        | 1/4 x 4                                       |

**Note** [1] Sizes 0 and 1 cannot be used with cast iron or G plastic caps.

**Table 21-6 Cast Iron Caps, G Plastic Caps, U Cable Guard Sizes, and Cable Diameters**

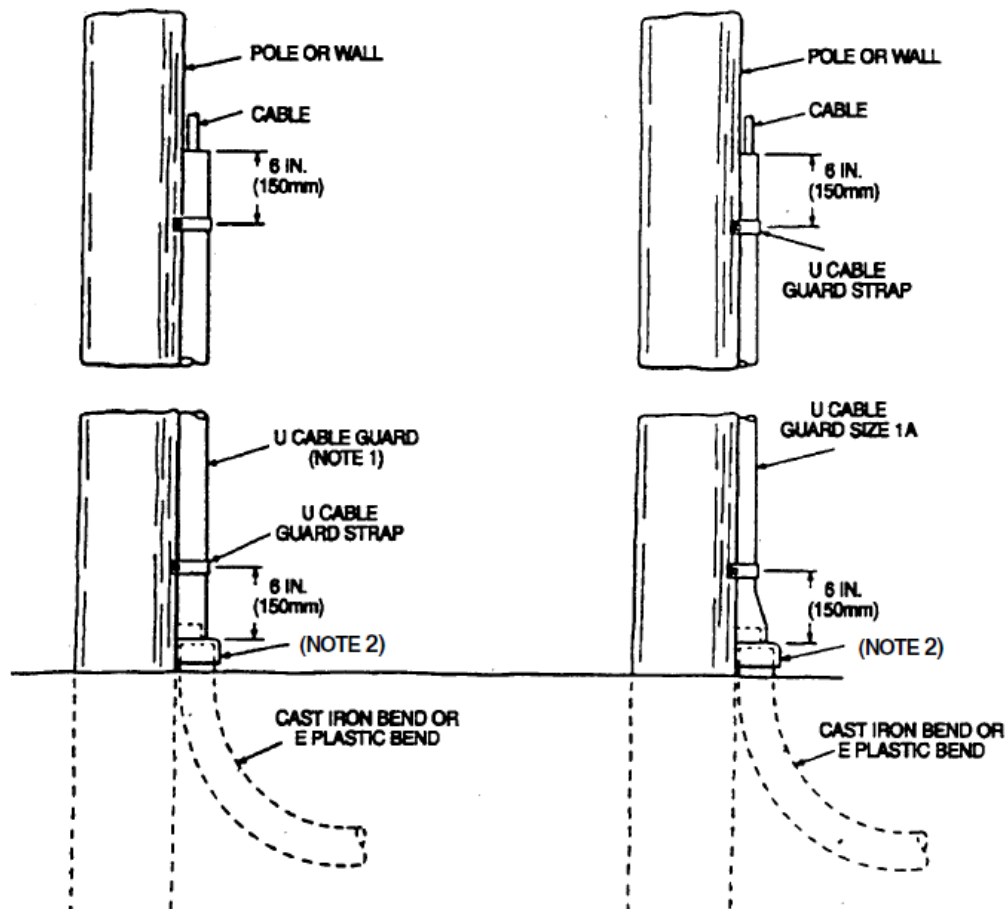
| Cap Size [Note 1] |            | Used With                                                          | Cable Diameter Up To and Including |
|-------------------|------------|--------------------------------------------------------------------|------------------------------------|
| Cast Iron         | G Plastic  |                                                                    |                                    |
| 2 x 2 inch        |            | 2-inch Conduit and No. 1A U Guard 2-inch Conduit and No. 2 U Guard | 1-1/8-inch 1-5/8-inch              |
| 2 x 3-1/2 inch    |            | 3-1/2-inch Conduit and No. 2 U Guard                               | 1-5/8-inch                         |
| 3 x 3-1/2 inch    |            | 3-1/2-inch Conduit and No. 3 U Guard                               | 2-5/8-inch                         |
|                   | 2 x 4 inch | 4-inch Conduit and No. 2 U Guard                                   | 1-5/8-inch                         |
|                   | 2 x 4 inch | 4-inch Conduit and No. 2 U Guard                                   | 1-5/8-inch                         |
|                   | 4 x 4 inch | 4-inch Conduit and No. 4 U Guard                                   | 3-1/8-inch                         |

**Note** [1] The first number of the size designation gives the associated U Guard number. The second number gives the conduit size.

Before placing the U cable guard, secure the cable to the pole or wall with cable straps, except for the length of cable that will be covered by the cable guard. Place the U cable guard as shown in Figure 21-3. The material required to attach the U cable guard to the pole or wall is listed in Table 21-5.

Standard practice is to use an 8-foot U cable guard on a pole and a 5-foot U cable guard on a wall. When it is necessary to provide mechanical protection for a height greater than the height covered by one U cable guard, a second one can be placed overlapping the first one for a distance of about 5 inches. Place the U cable guard straps 6 inches from the top and bottom of the second U cable guard, and 6 inches from the bottom of the first U cable guard.

**Figure 21-3 Cable Guard Installations**



**Notes:**

1. U Cable Guard size 2, 3 or 4.
2. Solvent weld this joint when G plastic cap is used with plastic bend.

## 21.9 Conduits for Vertical Risers

Transition cables or cable stubs are used to pneumatically isolate two sections of plant; within underground plant or between underground and aerial plant. These cables may be used between pressurized and non-pressurized cables or to transition between two non-pressurized cables of varying construction is covered in GR-421-CORE, *Generic Requirements for Metallic Telecommunications Cables*.

Transition cables between aerial plant and underground/direct-buried plant can be attached directly to the pole with clamps or be protected inside conduits. If there are several of these vertical riser cables on a single pole, the cables can be consolidated under a U-guard and a larger sized conduit. One can also be segregated by cable type and technology with separate ducts for (a) twisted pair copper cables, (b) optical fiber cables, and (c) a third conduit for any powering cables. Using separate conduits for these different cable types is based on the different pulling tensions, cable weights, bending characteristics, abrasion resistances, and power protection needs of these different cable types.

For these U-guards and conduits, it is advisable to seal the top ends as discussed in [Chapter 20](#) to minimize the entrance of water and contaminants down the vertical riser, or otherwise ensure that any water entering is efficiently drained away.

A build-up of water may result in ice formation in the bend during the winter months that can cause damage to a cable. The possibility of trouble from water ingress and the formation of ice can even extend into the underground closure.

## 21.10 Informative References Related to Direct-Buried Plant

Reference documents that provide functional performance requirements for these conduits are:

1. GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit and Accessories*, which contains a discussion on and references for SDR sizes in Section 2.3 and Table 2-1, where size (SDR) classifications and recommended sizes for applications are provided, and includes some compression criteria in Section 4.3.3. Other requirements in Section 4.3 of GR- 356 pertain to pulling strength and other mechanical robustness needed for the application.
2. GR-3155-CORE, *Generic Requirements for Single/Bundled Microducts and In- Living Unit (ILU) Cable Pathways*, which covers single and bundled microduct products.
3. GR-902-CORE, *Generic Requirements for Handholes and Other Below-Ground Splice Vaults*.
4. ANSI/SCTE-77, *Specification for Underground Enclosure Integrity*.
5. American Association of State Highway and Transportation Officials (AASHTO) specifications:
  - A Policy on Accommodation of Utilities within Freeway Right-of-Way.
  - Standard Specifications for Highway Bridges – H-10 and H-20 ratings.
6. ASTM C857, *Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures*.
7. ASTM C1037, *Standard Practice for Inspection of Underground Precast Concrete Utility Structures*.
8. Telcordia (Bellcore) Practice, BR-638-200-015, *Buried Cable Shield Continuity - Joint Buried Plant* (1987).
9. Telcordia (Bellcore) Practice, BR-627-020-005, *Bonding and Grounding - Aerial Plant (Metallic Conduit and Optical Fiber Cable) - General* (1986).
10. Telcordia (Bellcore) Practice, BR-629-100-010, *Buried Plant: Precautions and Maintenance in Existing Systems* (Issue 3 - 1993).
11. Telcordia (Bellcore) Practice, BR-917-356-101, *Buried Cable Systems - Joint Random Separation* (Issue 3 - 1991).



## 22 High-Air-Speed Blown Cable (HASB) Installation System

### 22.1 General

This chapter covers the description and application of the High-Air-Speed Blown Cable (HASB) system, which is used for placing optical fiber cables in innerduct used in underground (conduit), direct-buried, or aerial plant. This chapter describes the features and advantages that distinguish HASB from other cable-placement systems. It also provides guidance on the best practices and methods of operation.

**Note:** Additional information is available in Section 4.3 of the ASCE Manual and Reports on Engineering Practice No. 118, *Below-Ground Pipeline Networks for Utility Cables*.

The HASB system uses air flow maintained at high pressure (nominally up to 100 psi gauge) at the “cable-feed” end of the innerduct while the cable is inserted into the duct. Other systems also use air pressure, but they use it to install pull line or cables into ducts, and they use a piston or “parachute” mounted at the leading end of the line or cable. The HASB system has no significant obstruction mounted in front of the cable that could impede the flow of air through the innerduct.

In an HASB system, the large pressure gradient and viscous drag forces of the high-speed air on the lateral surface of the cable imposes a forward force on the cable without generating significant tensile loads. For this reason, the resulting placement distances achieved using the HASB technique are essentially independent of the presence of route bends or curvature within the innerduct. In addition, the process does not require pull line.

This chapter also provides information regarding appropriate procedures for innerduct construction and cable placement when the HASB system is employed.

The present general operating instructions are intended to be “high-level,” that is, they were written without regard to specific HASB models. Detailed “low-level” or step-by-step instructions for particular HASB systems shall be provided by the equipment supplier.

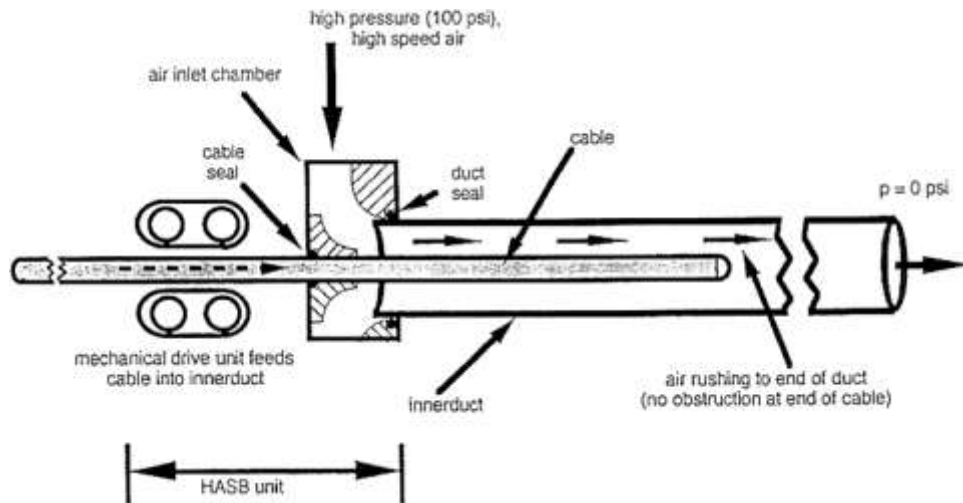
## 22.2 Product Description

This section presents a description of the HASB system. [Section 22.2.1](#) discusses principles of operation. [Section 22.2.2](#) describes the typical equipment necessary for cable placement using the HASB system.

### 22.2.1 Principle of Operation

The HASB system is based on the application of a placement force that is distributed along the length of the cable in the innerduct, as opposed to a concentrated force applied only at the end of the cable. The distributed force needs only be sufficient to overcome the frictional forces that result from the weight of the cable as it is dragged along the bottom of the duct. Systems that use a pulling force, such as applied by a pull line attached to the leading end of the cable, generate tensile forces in the pull line and the cable. Such tensile loads increase the bearing pressure of the pull line and the cable against the innerduct walls at curves and bends, leading to escalating frictional forces beyond that generated by the weight of the cable itself. The corresponding cable-placement distances are therefore limited by the maximum available force that can be readily applied, or that the pull line, cable, or innerduct system can tolerate.

In the HASB system, high air pressure (nominally 100 psi) is maintained at the “cable-feed” end of the innerduct as the cable is inserted into the duct opening. Since there is no piston or other significant obstruction mounted at the leading end of the cable that would impede the flow of air through the innerduct, the large pressure difference between the opposite ends results in high-velocity air flow as the air rushes out the far end of the duct. In order to maintain high pressure at the feed end, a relatively large air compressor, with a capacity of several hundred Cubic Feet per Minute (CFM), is required. The large pressure gradient and viscous drag forces of the high-speed air on the cable jacket apply a forward force on the cable sufficient to overcome the frictional force. The only friction generated is that of the cable sliding along the duct surface. The HASB system accomplishes this without generating significant tensile loads. The absence of significant tensile loads avoids high bearing pressures at the walls of the innerduct, and the resulting placement distances are therefore essentially independent of the presence of route bends or curvature. Low frictional characteristics between the cable and innerduct surfaces are still an important factor. Therefore, pre-lubricated duct (possibly supplemented with a small amount of compatible lubricant “blown” through the duct system prior to the cable installation) is recommended.

**Figure 22-1 Schematic of HASB Operation**

A mechanical drive unit is used to continuously feed cable into the innerduct, providing sufficient “push” force to balance the high internal pressure at the entrance of the pressurized system. Within the allowable axial compressive limits of the cable, this drive unit can apply additional assistance to help overcome system degradations produced by insufficient air flow, cable stiffness, etc.

In general, placement distances of several thousand feet are possible using a single HASB system consisting of one air inlet chamber plus a drive unit. The use of additional HASB units at intermediate points along the route allow greater unspliced lengths of cable to be placed.

The following formula may be used to provide a conservative estimate of the placement distance, L (ft), using a single HASB unit:

$$L = P \times DC \times DD / (W \times CoF)$$

where,

P = the applied air pressure (e.g., 100 psi) W = the cable weight (pounds per ft)

CoF = Coefficient of Friction (e.g., 0.1)

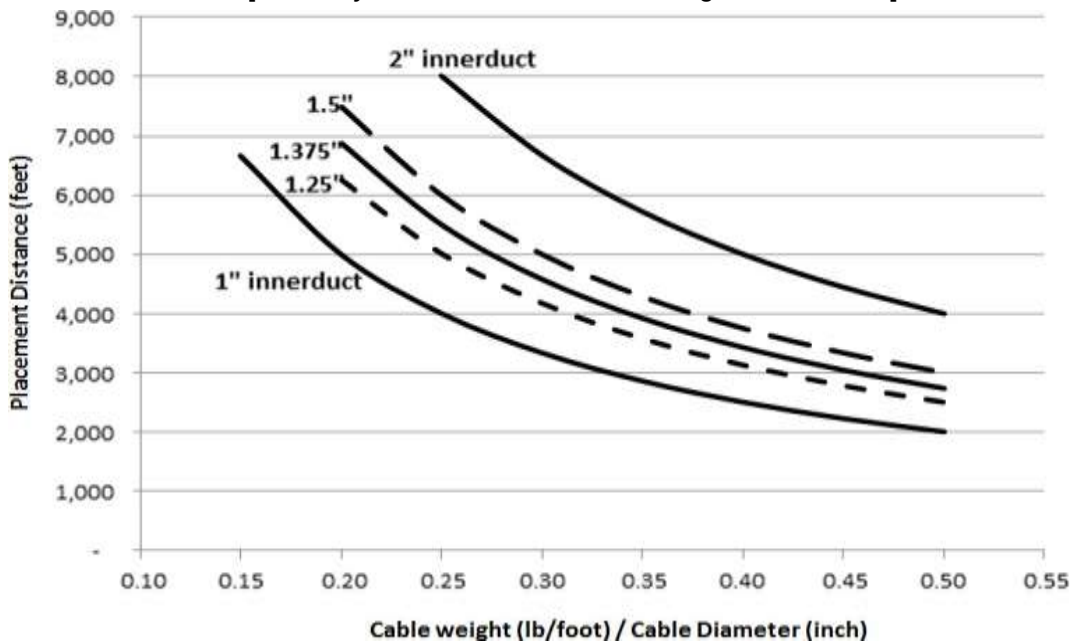
DC = Cable outer diameter (inch)

DD = Duct inner diameter (inch).

Figure 22-2 illustrates typical placement distances, depending on the cable characteristics and innerduct size.

**Figure 22-2 Typical Cable Placement Distances (Single HASB Unit)**

[Courtesy of Outside Plant Consulting Services, Inc.]



The factors that affect the maximum placement distance in one operation are a combination of:

- The inner diameter of the duct or conduit
- The cable size and its weight per foot
- The number of bends in the duct/conduit run
- The Coefficient of Friction (COF) between the cable and duct inner surface.

The larger the ratio of duct diameter to cable size, the easier the cable can be carried along and lower drag forces will occur. The lighter the cable (lbs per foot), the less will be the force required to push it along the duct. This is one of the reasons that this method is more popular for lightweight optical fiber cables compared to the heavier twisted-pair copper cables. Bends in a cable (particularly 90-degree bends) will increase the frictional forces significantly. Therefore, sharp bends should be avoided in general, and any necessary direction changes should be accomplished as smooth curves with as large a radius as practical. One can modify the COF by adding lubricants and using

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ducts with corrugated (grooved) inner surfaces. However, any lubricants used need to be compatible with cable jackets and duct materials and need to be tested to ensure they do not interfere with the mechanical drive components and seals in the equipment.

Note that systems with a “leaky” piston at the leading end of the cable incorporate some viscous drag effects. These effects are a result of air flow through the leak. There will be some pulling force at the end of the cable, as well as a push force produced by the mechanical drive unit. Maximum placement distances will then depend on the degree of leakage around the piston and the route curvature. Such systems are not considered in this issue.

### 22.2.2 Equipment Description

A single HASB system comprises an air inlet chamber and a mechanical drive unit that is hydraulically or pneumatically powered. If hydraulically powered, a separate power pack is required. If pneumatic, the same air compressor that supplies air to the duct powers the drive unit. The air inlet chamber typically disassembles into upper and lower halves, allowing placement or removal over a continuous section of cable. The chamber also has replaceable inserts that can be selected to match the innerduct and the cable outer diameters for any installation. Gaskets prevent excessive air leakage at the outer diameter of the duct, at the cable feed portal, and at the seams of the unit. The duct is grasped securely to prevent slippage during the application of the air pressure and cable installation.

The required air compressor is provided separately and should be of sufficient capacity to maintain a pressure of 100 psi at the feed end of the innerduct. The required capacity will be at least several hundred cubic feet per minute, depending on the duct diameter. A hose from the air compressor attaches to the air inlet chamber. The pressure can be turned on from a valve on the air chamber.

The mechanical drive unit consists of tractor treads or drive wheels that grip the cable on the sides and feed it into the innerduct through the air inlet chamber. The cable can be inserted between the upper and lower sections of the drive. The force of the drive is controlled by a valve that regulates the hydraulic pressure or air pressure to the mechanical drive unit. The cable is fed into the drive unit, which in turn pushes the cable into the pressurized innerduct.

When additional HASB units are used as “mid-assists” (i.e., when they are used at intermediate access points along the route), it will be necessary to duplicate the above setup at each of these stations.

## 22.3 HASB Method of Cable Placement

This section describes the cable-placement procedures for the HASB method.

- [Section 22.3.1](#) – General preparation of the HASB unit
- [Section 22.3.2](#) – Procedures for installing and setting up the HASB unit
- [Section 22.3.3](#) – Cable installation procedure.

### 22.3.1 Preparation

In general, compatible innerduct types include smooth-wall and internally and longitudinally (straight or spiral) ribbed ducts that are capable of withstanding an internal hydrostatic air pressure of 125 psi.

**Note:** Corrugated innerduct is not suitable for the HASB method of placing cable.

In preparation for using the HASB method of placement, the innerduct must be properly secured to avoid unnecessary movement. The duct couplings should be airtight, and they must be able to withstand 125 psi of air pressure.

---

**! CAUTION !** *Improper couplings may leak severely and/or slip off during pressurization or cable placement.*

---

**Note:** The use of “multi-duct” conduit (i.e., conduit consisting of short lengths joined together in the field) may not be appropriate with the HASB technique because of the high degree of reliability required for the multiplicity of couplings. It is also not clear whether minor transverse “ridges” (or gaps) and the larger number of innerduct joints degrade system performance.

Prior to employing the HASB method of cable placement, the operators should be familiar with the supplier’s guidelines and instructions. HASB systems may vary somewhat in design, capabilities, and operation details. The present general procedures are intended to apply to most HASB systems.

When several HASB models are available from a given supplier, choose the model recommended for the range of cable sizes being placed. Using the right model for the particular cable size will avoid potential damage to the cable.

---

**! CAUTION !** *The use of an oversized HASB drive unit for placing cable with a relatively small diameter may result in cable damage if the unit is improperly operated.*

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It is important that the HASB unit be inspected for proper lubrication. It must also be fitted with all necessary duct inserts before installation begins. The cable and innerduct size and type must be known to determine the correct sealing inserts at the air inlet chamber. Seals are required to prevent air leakage at the seams of the housing, the exterior of the duct, and the cable entry.

**Note:** It is recommended that a cable sample be tested with the HASB system before the actual cable placement, as follows:

- First, connect a 20- to 30-foot length of representative duct to the HASB unit.
- Following the relevant instructions in [Section 22.3.2](#), place a cable sample into the unit.
- With the far end of the duct blocked to prevent cable movement, engage the drive unit so that it attempts to push the cable at the maximum drive-force setting, as recommended by the HASB supplier.
- The unit should halt without slippage at the cable sheath.
- The cable should be checked for visible damage (e.g., kinking or surface abrasion), and the drive-force setting should be reduced as necessary.
- The air compressor is not used during this test.

An auxiliary compressor must be provided with the necessary hoses and fittings for each HASB unit. The air compressor unit should have a rating of 110 psi or greater when under its rated load. [Table 22-1](#) indicates recommended (minimum) compressor capacities.

**Table 22-1 Minimum Recommended Air Compressor Size**

| Nominal Duct Size | Compressor Size<br>Cubic Feet per Minute (CFM) |
|-------------------|------------------------------------------------|
| 1 inch            | 185                                            |
| 1-1/4 inch        | 250                                            |
| 1-3/8 inch        | 375                                            |
| 1-1/2 inch        | 425                                            |
| 2 inch            | 600                                            |

In cold temperatures, an air dryer accessory is recommended to avoid introducing water condensation into the HASB air inlet chamber or innerduct network.

Condensation may result in frost. In hot temperatures, an air cooler is recommended to avoid excessive temperatures at the duct and cable.

For proper airflow, the end of the duct must be kept open during cable

placement. When intermediate HASB units are used along the route, follow the supplier's specifications for the correct innerduct connections at each intermediate unit.

### 22.3.2 HASB Set-Up

When installing the HASB unit, the unit should be placed close to the manhole, trench, or aerial location, and it should be aligned with the innerduct opening and cable reel. The unit should then be secured with ties or clamps to avoid movement.

Once the HASB unit is secured, send the duct fully into the entrance guide of the air inlet chamber and secure it tightly. Be sure to use the correct duct inserts and seals.

Before installing the hydraulic hoses (if required) to the HASB unit, check to ensure that the couplings at the ends of the hoses are clean. When the unit is not in use, apply protective caps.

Following the supplier's recommendations, adjust the gripping force of the drive unit so that it is consistent with the cable diameter.

---

**! CAUTION !** *Incorrect adjustment of the gripping force may result in improper operation and/or cable damage.*

---

Place the cable into the drive unit and air inlet chamber (disassembled if necessary). The cable will prevent excessive air from leaking out of the cable-entry portal. To avoid cable snagging in the duct, attach a rounded cap, or equivalent, to the cable end. Be sure to install any recommended cable guide/sleeve between the air inlet chamber and the drive unit.

---

**! CAUTION !** *The cable guide/sleeve that supports the cable between the drive unit and the air inlet chamber must be properly installed. Pushing forces applied by the drive unit could damage the cable if the guide/sleeve is not properly installed.*

---

If the innerduct is not pre-lubricated, a proper liquid lubricant must be provided. Relatively little lubricant is required for use with the HASB system. Follow the recommendations of the supplier of the HASB system regarding the type and amount of lubricant to use. In general, it is recommended that a compatible lubricant should be used for supplementing pre-lubricated duct. Pour lubricant directly into the duct, and not into the air inlet chamber. Insert a foam plug into the duct opening. The lubricant will be spread evenly by blowing foam plugs through each innerduct section. (See [Section 22.3.3, "Cable Installation."](#))

**Note:** Excessive lubrication of the duct may have a negative effect on the performance of the HASB unit.



Push the cable by hand into the duct approximately 20 to 30 feet. Push any foam plugs (if lubricant was added) into the duct.

**Note:** It is especially important for the ducts to be clear and clean. The HASB system uses relatively low installation forces, and minor obstructions may impede the cable-placement process.

If you suspect excessive water or dust in the innerduct, the duct should be cleaned several times if necessary prior to adding any lubricant. This can be accomplished by placing a foam plug in the duct, which will be blown through the innerduct section. See [Section 22.3.3](#). In this case, do not place the lubricant into the innerduct until the cleaning process is complete.

**Note:** Be sure the cable is pressing correctly against the drive mechanism (e.g., rollers or caterpillar tracks) and is centered.

Tighten and close the drive unit and air inlet chamber.

If additional HASB units are used at mid-assist points, follow the same procedures as previously described at each HASB location, as appropriate. In this case, the far (downstream) end of the duct that is to be connected to an intermediate HASB unit should be secured, but not terminated, in the intermediate unit until the foam plug and lubricant are blown through the upstream segment. A special plug provided by the HASB supplier, or a cable sample securely held by the local drive unit, can be used to prevent air leakage from the cable-entry portal.

**Note:** While working in a manhole or below ground, attach a flexible hose to the exhaust of the duct or the intermediate HASB unit and extend it above ground.

### 22.3.3 Cable Installation

Before starting the compressors, perform the following checks:

1. Make sure that all air hoses and pipe fittings are properly installed and tightened. Always use safety clips at hose connections.
2. Inspect duct ends to ensure that they are clamped and secured.
3. Make sure that the air inlet valve on the HASB unit is closed. The separate main valve at the air compressor should also be closed.
4. Ensure that communications are working at all stations and that start and stop signals are understood.
5. Make sure that all personnel are wearing proper eye and ear protection. A respirator or particle mask is recommended to protect against expelled lubricants.
6. Warn all downstream personnel before the air is turned on.

**Note:** It should be obvious that one should never stand in front of the duct end when the air is turned on. Escaping air and expelled lubricants can

cause personal injury, especially eye injury. Never look directly down the duct during the cable installation operation.

Turn on the air compressor. Open the air compressor valve and then the air inlet valve of the HASB unit. After opening the air inlet valve and pressurizing the system, ensure that the innerduct is not slipping out of the duct clamp. Allow the sponges to expel any water or dust. If the sponges are being used to spread lubricant through the innerduct section, allow them to do so now. It is also important to check duct integrity at this time.

A strong air flow at the far end and a pressure reading of close to 100 psi are indications of innerduct integrity. Any visible or accessible couplings should be inspected for excessive air leakage. Faulty couplings should be repaired or replaced, as necessary. For particularly short routes, it is possible that a relatively low operating pressure may exist at the HASB unit and yet still be adequate for successful cable placement. However, optimum operation is based on 100 psi at the air inlet chamber.

---

**! CAUTION !** *If at any time it is necessary to disassemble the HASB unit, close the main valve at the air compressor first. This will allow the air within the hoses and the innerduct system to bleed out before you close the air inlet valve of the HASB unit. The pressure gauge at the HASB air inlet chamber can be used to monitor the air pressure level.*

---

If a preliminary cleaning operation is being performed (see [Section 22.3.2](#)), it will be necessary to disassemble the HASB unit to add lubricant and/or insert the cable into the duct prior to actual cable installation, as described in [Section 22.3.2, "HASB Set- Up."](#) Then proceed as above.

Turn on the drive unit motor gradually until the cable starts to move. Do not exceed the maximum recommended drive-force setting provided by the supplier of the HASB system, and do not exceed the setting determined during the preliminary test described above.

Be sure to keep slack between the cable reel and the HASB unit during cable placement. The reel should be rotated during the installation to avoid backload on the drive unit. Avoid excessive cable-placement speed. Satisfactory operating speeds are typically 150 to 200 ft/min. During placing operations, the air flow should be monitored at the intermediate and terminal locations. The cable-placement progress should also be monitored.

**Note:** If the air flow or cable movement stops for any reason, immediately stop all placing operations and shut off the power to the drive units. Any air leaks must be repaired prior to continuing the cable-placement operation.

**Note:** Whenever cable placement is interrupted, loosen the drive unit until there is no applied force on the cable, and pull out some slack to relieve the axial compressive strain on the cable within the duct. Re-tighten the drive unit when you are ready to continue cable placement.

When the cable reaches its destination, sufficient slack should be provided for splicing. If desired, short segments of innerduct can be carefully cut away at additional access points to expose the installed cable. If additional cable slack is required at these locations, start by first removing a duct segment from the farthest desired slack location from the HASB unit. The HASB unit can be used to slowly feed the cable until the desired slack is obtained. Continue working backwards (upstream) toward the HASB unit until the required slack is obtained at all desired locations.

If several HASB units are required at intermediate mid-assist points (as may be required for very long installations), communications and coordination among the sites is essential. In general, similar preparatory steps are required at each HASB unit as described previously. As the cable exits from each upstream route segment, it is inserted into the local HASB unit feeding the subsequent downstream segment. Follow the supplier's instructions regarding proper synchronization. Typically, the HASB units are activated sequentially, in a cascade fashion. Working upstream, first turn on the farthest unit from the nearest (cable-reel/feed-end) site. This is the site that controls and issues commands for the overall operation.

## 23 Direct-Buried Innerduct Construction Guidelines

### 23.1 General

This chapter provides construction guidelines for direct-buried, semi-flexible duct (innerduct) applications in the local loop distribution plant. Buried innerduct is a cost-effective means to allow the distribution and service wire portions of the network to be upgraded without a need for difficult and possibly expensive digging operations in the future. Such upgrades include later installation of optical fiber or other cables (and distribution terminals) to provide advanced services, when appropriate. The duct also enhances visibility and provides some physical protection from unrelated construction activities. In case of damage to the innerduct and internal cables or wires, the (repaired) innerduct allows convenient replacement of the damaged items.

This chapter also provides recommendations for the appropriate type and size of innerduct for the particular application. Possible field applications are also briefly discussed.

A new section 23.8 covering cable pulling operations (e.g., appropriate tensions and effect of bends in duct/conduit line) for placing the cable through duct or conduit has been added for this 2023 edition.

### 23.2 Applications

One important application for the use of buried innerduct is to provide the basis for an upgradeable distribution plant, e.g., to facilitate the future installation of Fiber-In-The-Loop (FITL), Fiber-To-The-Premises (FTTP), backhaul communications for wireless facilities, or other broadband systems. Thus, innerduct could be placed during the initial (new-build) construction stages for present-day conventional copper transmission facilities being installed in open trenches. At this time, a vacant duct may readily be placed in the main distribution trench parallel to the present copper distribution cable to permit possible future placement of a fiber distribution cable. Additional vacant ducts may also be desirable for possible future auxiliary cables, such as a separate copper distribution cable to provide direct-current (dc) power for the FITL system.

The present service wire may be placed within an innerduct routed from the vicinity of the present copper distribution pedestal to the living unit. The duct may be placed within the main trench and then be extended directly to the residence through the lateral trench to the living unit. Future required wires can later be placed within this same (occupied) duct to supplement or replace the original service wire, as required. It is also possible to place the original service wire directly in the trench, alongside (outside) a vacant innerduct installed for future service wires. In this case, physical protection is not provided to the original service wire.

Some suppliers will provide service wire pre-installed within the innerduct or attached to the outside of the duct to facilitate the overall process.

**Note:** Duct should be routinely used for service wire in all new FITL or broadband construction to provide flexibility to meet future service wire requirements.

For previously constructed areas requiring replacement or upgrade, the use of innerduct isolates the new cables or wires from stresses present during various “trenchless” construction methods. This includes the use of “mini-horizontal directional drilling” for pulling back a utility duct into a bored (unlined) hole along the main distribution route, and vibratory plowing for which a pull-plowing technique is used to tow a service-wire utility duct into a small tunnel created by a “bullet” attached to the bottom of the plow blade beneath the surface. The newly placed innerduct also provides subsequent physical protection and allows for future addition or replacement of service wires, as required.

The particular strategy for terminating and accessing the buried innerducts, and generally optimizing the use for present and future operations, will depend on local preferences and conditions, and anticipated cable installation techniques. For example, the HASB placement system, combined with a temporary innerduct loop connecting the upstream and downstream sides of “distribution” ducts entering each pedestal closure, provides a convenient means of later placing a fiber distribution cable through several adjacent pedestals along the route.

## 23.3 Duct and Innerduct Types

### 23.3.1 General Considerations

Corrugated duct of any size is not appropriate for direct-buried applications. Corrugated duct in a trench will have relatively large undulations, and its less-rugged construction may cause problems during installation or usage. The transverse ribs are not compatible with the HASB technique since they inhibit the airflow from applying the desired viscous drag forces to a cable; also, the relatively thin wall construction may not withstand the operating pressure of 100 psi or greater. Smooth-wall or internally ribbed (straight or spiral) innerduct that can withstand air pressure of 125 psi is acceptable.

Pre-lubricated duct should be strongly considered. The type of duct and lubricant used should be recorded to avoid compatibility problems in case additional lubrication is used in the field during actual cable placement. Unless it is known that a traditional pulling method will not be used, it is recommended that the innerduct be ordered with a factory-installed, low-friction pull line to eliminate potential problems in later “rodding” of the duct (i.e., installing the pull line) before actual cable or wire placement. The “free movement” of the pull line can also be used to verify initial integrity of

the path, as a check on the construction process.

High-density polyethylene innerduct is recommended (ASTM D3035) because the controlled outside diameter facilitates coupling of adjacent sections due to its relatively thick wall construction. Black duct with orange stripes resists UV damage and increases visibility to help avoid damage from future construction activities. Solid orange duct is acceptable if no portions of the duct are exposed to direct sunlight.

**Note:** See GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit, and Accessories*, and its cited references. Also see Sections 20.1, 20.14, 21.2.6, 27.2.4 and 27.2.6 for related discussions on deployment of conduits, ducts and microducts.

New varieties of bundled microduct products have been developed with direct-buried applications in mind, particularly for deployments of optical fiber and to service some wireless/antenna facilities. See [Section 27.2.7](#) for descriptions of these products for optical fiber networks, and Chapter 20 (Sections 20.1 and 20.14) for general discussions on microduct applications.

### 23.3.2 Metallic Service Wire

For service wire applications, a minimum duct size of 3/4-inch (nominal inside diameter) is recommended. Smaller sizes are not generally compatible with the installation (or removal) of two or more service wires (e.g., twisted pairs and coaxial cable, corresponding to future possible media requirements). Also, if there is a future need to pull in a pre-connectorized fiber service wire, this would be considerably more difficult in a smaller duct.

**Note:** The use of 1/2-inch duct generally restricts upgrade capability.

### 23.3.3 Distribution

For buried distribution cable applications, the 1-1/2-inch duct size is convenient and compatible with either traditional cable-pulling or HASB techniques. Smaller diameter duct tends to display greater undulations in buried applications; larger sizes (e.g., 2-inch diameter) are acceptable, but are more difficult to handle, and may allow excessive fiber-cable bending within the innerduct if the HASB system is being used, possibly reducing cable placement distances. As a general rule, the cable size should be limited to approximately 2/3 of the duct diameter. The installation of a required number of copper pairs may necessitate placement of several (spare) ducts, each allowing for a copper cable of up to 1 inch in diameter (approximately 75-pair, 22-AWG) in a 1-1/2-inch duct. The use of a 2-inch duct would correspond to a 150-pair, 22-AWG cable. In all cases, a separate duct is assumed for the fiber distribution cable.

## 23.4 Innerduct Installation Methods and Practices

### 23.4.1 Planning

The “One-Call 811 Center” (also see [Section 2.8](#)) and/or a local utility location and coordination committee active in your area must be notified of scheduled construction activities no less than 48 hours before a subsurface operation. The One-Call Center will notify other subsurface facility operators to locate and mark their plant in the vicinity of the route before construction begins.

It is of utmost importance that all applicable safety procedures be followed when excavating in the vicinity of joint-buried plant.

### 23.4.2 General Considerations

Various construction methods are available for buried installation of the innerduct, as described below. The most appropriate method will depend on factors such as whether the installation is new construction or upgrade/rehabilitation of an existing area, customer impact versus costs, soil conditions, and other factors peculiar to each distribution area. Specific details for installation of innerduct are different for distribution cables and service wires.

Although innerduct provides some protection to the cable or wire, the following minimum depths consistent with ANSI/EIA/TIA-590, *Standard for Physical Location and Protection of Below-Ground Optical Fiber Cable Plant*, should be maintained where possible:

- Service or drop wires below 18 inches
- Distribution wires or cables below 24 inches.

These recommendations may be superseded by local and state laws.

During the installation process, care should be taken to avoid sharp bends that can kink the duct. The supplier’s guidelines should be followed with respect to minimum bend radii and other handling practices.

The use of appropriate duct plugs or caps and coupling accessories during or immediately after the innerduct placement is important to ensure the long-term integrity of the completed system. This is especially significant when the innerduct

network includes vacant paths for use in future upgrades, such as to Fiber-In-The- Loop (FITL). Couplers should be waterproof and, for ducts terminated below ground, the ends of the innerduct should be protected by watertight plugs or sealing compound to prevent entry of water or debris. Ducts terminated above ground should have caps placed over the ends. Special plugs or caps may also be used at the ends of ducts that contain cables or wires.

**Note:** It is recommended that distribution duct couplings be airtight and able to withstand an air pressure of 125 psi to be compatible with the HASB technique (see [Chapter 22](#)).

If any route couplings or joints will not be accessible in the future, and it is anticipated that the HASB system may be used, it is recommended that the particular route section be subjected to a pressure test before completion of construction. With one end of the innerduct section securely plugged, the opposite end connected to a 100-psi air compressor, and an auxiliary pressure gauge directly measuring the pressure in the duct, the air compressor should be turned on to pressurize the section.

**Note:** A general principle of safe operation includes making sure that no personnel are in the vicinity of the plugs, connections, or any couplings.

Several minutes should be allowed for the pressure to stabilize, then the air compressor valve should be shut and the compressor turned off. If the pressure in the duct drops by more than 20 psi in 2 minutes, the route should be checked for leakage, repaired, and re-tested.

It is also recommended that the upgrade capability for service wire be occasionally verified immediately after placement of the duct, especially for routes that approach the proposed limits for service wire length or number of bends. This can be done by simultaneously pulling anticipated service wire(s) through the vacant duct, thereby maintaining a process control on methods and materials. As a minimum, verification should be performed after one of the early installations and after any significant changes in materials, procedures, or installation conditions.

### 23.4.3 Trenching

Before trenching begins, the soil conditions should be identified so that proper protective measures may be planned in advance of the excavating work. The requirements for these measures will differ depending on the soil conditions.

To maximize the effectiveness of the buried innerduct, the following procedures should be adhered to maintain a reasonably even trench bottom: clear all large rocks greater than 1-1/2 inches from the immediate vicinity of the duct, feed the duct off the bottom of the reel, and have only one person place the duct in the trench. It is suggested that the duct be pulled somewhat taut during the backfill process. This will generally reduce the degree of curvature that is caused by the “reel memory” characteristics of the particular product, especially for duct sizes less than 1-1/2 inches.

**! CAUTION !** *Excessive tension on the innerduct may cause distortion or necking.*



## 23.5 Microtrenching in Urban Environments

In congested urban locations, buried or underground construction activities are complicated by factors such as the

- Density of several different underground utilities under busy roads and streets, including communications, power, water, sewer, natural gas, steam lines, etc.
- Presence of transportation infrastructure, including tunnels for pedestrians, trains, and subways.
- Associated safety and traffic control precautions requiring not only accurate location of adjacent utility lines, but also the assistance of the local police force and permit restrictions.
- High cost of trenching, roadway excavation, and pavement cutting along with the associated remedial work after the work is completed.

These and other factors contribute to prolonging a project, as well as increasing the excavation and construction costs in busy urban settings.

The desire for universal broadband coverage has increased the amount of excavation work for the installation of new buried and underground communications plant, as well as above-ground antenna developments.

The desire for ubiquitous cell-phone and wireless coverage has required communications providers to place antennas in more and more locales. In contrast to traditional cell-tower systems that desire to have maximum coverage for a single powerful transmitter-receiver site, Distributed Antenna Systems (DASs) are designed to have more antennas of lower power located in a micro-cell pattern to attain similar or better coverage. DASs are more often to be found inside buildings to minimize interference and dead spots caused by the steel and wooded structural elements of the building.

In addition, some municipalities and jurisdictions desire to have monitoring and control sites with antenna and camera equipment to help with traffic flow and security.

These installations will be expected to include (i) power cables for antenna and camera operations, (ii) several types of communications cables, including optical fiber (pre-connectorized), metallic twisted pairs and coaxial cables, and (iii) an antenna/camera site with an associated control box mounted on poles/towers or buildings where luminaries (street lights and traffic lights) may be in close proximity.

The distribution cables to the antenna/camera sites need to be placed primarily in underground or buried plant since aerial distribution of the cables is not feasible owing to lack of poles and appropriate aerial infrastructure in this urban environment. The high costs of this work may lead some companies to favor joint placement of power and communications cables in a single conduit in a microtrenching operation where a narrow trench (1-2 inch wide) is cut in the roadway to a shallow depth of 8-10

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inches. A small diameter conduit (1/2 to 3/4 inch) or microduct is then placed into the trench to provide service.

Despite the apparent cost savings, joint placement of power and communications cables in the same conduit or duct should be avoided if at all possible. Separate conduits should be used for the communications and power cables.

The suggested microtrenching placement techniques that place the conduits or cables at shallow depths (2 to 6 inches) may be effective for pedestrian only or light traffic zones. For roads and pavements where heavy traffic, accidental dig-ups, and other mitigating circumstances can be expected, the shallow depths are not likely to provide adequate long-term physical protection for cables even if the cables are inside the duct.

**The NESC does not prescribe the depth of communications lines.** However, related reference burial depth found in NESC Table 352-1 for low-voltage power supply cables is 24 inches, with an assumption that cables can be placed at shallower depths if supplementary protection is provided (Rule 352D2b). The added protection from having the cables being inside conduits or microducts does permit less depth to be used; however, 2 to 6 inches is considered too close to the surface to guarantee long-term protection. If these microtrenching techniques are employed, then the owner/operator should expect damage will occur because of mechanical stress, excavation events, and potholes that will develop after installation.

If a micro-trenched deployment has occurred to provide power and/or communications services to a wireless facility, then any One-Call 811 location requests for excavation work in the vicinity should be promptly and thoroughly responded to by the communications company. Both the location and depth of the microduct need to be stated clearly to the company doing excavation in the area to help prevent damage. Furthermore, a warning tape and additional barrier should be placed between the microduct and the surface.

An alternative to trenching could be to use directional drilling techniques to reduce the cost of “breaking pavement.” However, the below-ground zones within many cities are expected to be very crowded with other utilities and facilities. The logistics and safe procedures for drilling in such crowded spaces would include pre- construction surveys and careful mapping of other facilities in the area, as well as cross-checking by exposure of some of these facilities as described elsewhere in this document ([Chapter 23, “Direct-Buried Innerduct Construction Guidelines,”](#) and [Chapter 24, “Horizontal Directional Drilling \(HDD\).”](#))

If joint placement of power and communications cables in the same conduit cannot be avoided, then the buried segment of the network should comply with relevant NESC Rules 341, 344, and 354 for joint-buried situations, as follows:

1. The supply voltages should be kept below 300 V. If higher than 300 V, then additional protection devices and grounding systems (e.g., extra

protectors and arrestors) need to be in place to safeguard personnel in case of a power cross or fault event occurring.

2. All the cables in a single conduit should be owned, operated and maintained by one utility and serviced by qualified personnel who could be (a) a power technician with added optical fiber training, or (b) a communications technician who has received additional training to work on the power supply cables of the relevant voltages. The single ownership objective may prove difficult because of the wide range of stakeholders in this scenario, which includes the municipality, the communications company, the wireless company, the local power company, and possibly departments of police, disaster management, and homeland security, among others.
3. Communications cables should be configured so if a power fault occurs, the voltage on any communications circuit will not exceed 400 V to ground (see NESC Rule 344A4).
4. The communications cables shall have a continuous metallic shield under its outer jacket to reduce the interference and added noise from voltages/currents induced by the adjacent power supply lines (see NESC Rule 344A1). If the communications cable is an all-dielectric optical fiber, this condition is not necessary.
5. Where accessible, the communications cable shield (if present) and the power neutral shall be bonded together and grounded to earth at intervals of less than 1,000 feet. That is, the supply and communications circuits are bonded to a grounding system to help prevent buildup of voltages and to help activate protection devices in the case of a power fault.
6. Using conduits with multiple internal ducts or microducts may help provide the separation and identification of power and communications for mechanical and electrical protection as well as for safe and reliable operations. In this proposed case, color coding of the individual ducts would be advisable, with the red duct reserved for power cable. The major conduit should also be colored red or have a red stripe to help identify that the conduit contains a power cable. One should also add markings and printed information on the conduit to fully identify the contents and help a worker determine the appropriate best safe practice to follow when opening the conduit and individual ducts/microducts. A set of written practices for working on one cable while covering or insulating the other cable or duct is advised.

If joint communications and power plant are present, the operating company will need to expect that post-installation damage may occur and, therefore, an operator will need methods and procedures in place that will include the following if joint communications and power plant are present:

- Ability and capability to turn the supply power off while working on cables, and/ or

- Practices to cover/insulate power cables from communications cables during repair work operations
- Practices to properly ground metallic components of cables/equipment during work operations and remove grounds after work.

Access points or closures within the network serving these antenna/camera sites can be susceptible points where accidental contact with power is possible and exposure to environmental stresses (heat/cold/rain, etc.) will occur. Therefore, in any pedestal, manhole, handhole, or cabinet control box used as an access or maintenance testing point in the network, the following guidelines should apply:

- A 6-inch minimum clearance should be maintained within the access closure between supply and communications equipment (see NESC Table 341-1).
- Supply and communications cables should be racked or positioned within the access point to allow work on one without movement of other circuit, e.g., racked on opposite walls (NESC Rule 341B).
- It is preferable to have separate access boxes (one for power connection, and one for communications) and separate the individual conduits/microducts from the main conduit 12 inches away from the boxes.
- Adequate bonding and grounding of cable shields, power neutrals, and the metallic closure box shall be done, including a bond to available Multi-Ground Neutrals (MGNs), e.g., adjacent pole ground (NESC Rules 224 and 342).

At the antenna/camera site, the cables should be protected in conduit and/or under U-guard from ground level to the antenna/camera termination point. Inside any control box at the site, the power and communications circuits shall be kept on opposite sides of the box and be physically separated by an insulating barrier, if possible, inside the box.

See [Chapter 15](#) and [Section 3.7](#) of this *Blue Book* for further discussion on antennas and wireless facilities.

## 23.6 Plowing

Different plowing techniques are appropriate for installing innerduct for service wires and distribution cables.

For service wire, the use of a relatively thin blade with a “bullet” at the bottom to pull an innerduct beneath the soil is an effective means for neatly and efficiently installing the short lengths that are typically required for lateral portions of service lines. Plows of 35 horsepower or less can be used for such applications. In particular, small maneuverable lawn plows (25 horsepower or less) can be optimally used to install a duct in existing lawns, with minimal turf damage, similar to a sprinkler system installation.

Although these smaller machines generally cannot place duct 18 inches below the surface, the added protection and the maintenance capability represented by the duct, combined with the minimal turf damage, makes the use of this technique desirable for some upgrade situations. In general, plow operations at minimum ground speed and maximum vibratory rate will provide optimal results.

The push-plow operation will typically result in an innerduct path with smaller undulations than with a trenched installation.

For distribution applications, in contrast to service wire, the comparatively long distances involved and the possibility of damage to this critical link indicate that the pull-plowing technique should not be used for distribution placement because of the possibility of excessive stresses or deformation of the duct. However, sufficiently large plow equipment with an appropriately sized feed chute is acceptable.

## 23.7 Directional Drilling

Directional drilling, or more specifically, mini-horizontal directional drilling (mini- HDD), is a trenchless technique for boring small-diameter paths underground with little or no disturbance to the ground surface. With this method, a series of drill rods are pushed and steered, with the locations of the drill head continually being monitored to avoid known obstacles, to complete a path between two given points. A drilling fluid (such as bentonite, a type of clay) is usually used to stabilize the hole and provide lubrication. A secondary back-reaming operation simultaneously enlarges the hole as necessary and pulls in the utility line or duct. This installation method is often used when existing cables are being replaced in established areas.

Typical distances of several hundred feet can be drilled, which is sufficient for installing duct between distribution terminals (pedestals) or from the terminal to the home. The depth capabilities are considerably greater than distribution or service- wire requirements, and the resulting duct path has relatively small undulations.

However, small radius bends cannot be constructed directly, and multiple drill-rig setups may be required to install service-wire segments along the main distribution right-of-way and laterals to the home.

[Chapter 24](#) provides detailed information and guidelines for mini-HDD construction.

## 23.8 Cable Pulling

This Section provides general guidance on the pulling tensions and pulling distances that are useful to determine efficient pullbox (handhole, manhole)

spacing and placement and avoid tensile and abrasion damage to the cables during installation. A specific case study for optical fiber cable placement in new conduit runs with guidance on practices to minimize friction damage to the cables.

The discussion is provided on preferred locations for handholes/manholes along with review of the quantitative methods using mechanical engineering equations as well as graphical techniques based on empirical algorithms.

Information on the alternate placement methods of blowing cables through such ducts and conduits are found in Chapter 22. (*High-Air-Speed-Blowing or HASB*).

### General Location and Design Guidance

The designed route and specific placement of new conduit and access handholes for a buried or underground runs of cable depend on several design, engineering and operational factors including:

1. Information on other utilities regarding their existing and proposed underground facilities that do or could interfere with the conduit and handhole planned placement.
2. Results of any field survey of proposed route looking for any special construction problems such as river or railroad crossings, drainage ditches, driveways, necessary bends in the planned route, and other possible obstructions.
3. The selected (hopefully) permanent locations for underground structures including the conduit run and handhole/manholes need to consider factors such as :
  - a) Long-range outside plant planning and future requirements for growth of services.
  - b) Present and future requirements for subsidiary and branch conduit that may require handhole access points in certain preferred locations.
  - c) Future road developments and widening operations that may require movement of ill-placed handholes.
  - d) Kinds of road paving used along possible conduit routes that would increase construction costs and times significantly.
  - e) Need to avoid unstable soil conditions, foreign underground structures, and liquid and gas storage facilities.
  - f) Select locations for safety and convenience of workers and general public during the repair and maintenance of the line such as locating handholes and manholes away from busy road intersections.
  - g) Select the conduit size, design and material type based on customer requirements and to accommodate future network plans. Select conduit material on basis of minimum total cost. Size manholes and conduit for ultimate number of ducts or innerducts. Traditional wireline network plans were designed

around 40-year growth period but modern networks may have shorter time horizons for modifications to their buried/underground plant.

- h) Design the conduit placement so it is pitched towards handhole/manhole coupled with adequate drainage patterns and configurations to avoid problems of exposure of underground structure by soil erosion and interference with area drainage patterns.

Consideration of the various necessary bends and changes in pitch of the conduit runs are required to quantitatively address some of the above concerns and circumstances that can result in significant increases in frictional forces and mechanical stresses experienced by a cable being pulled through a conduit run. The design and locational factors that determine the desirable section lengths of conduit or duct between manholes or handhole or pull boxes include the following:

- A.) Location of intersecting main, subsidiary, and branch conduits - the closer to the main office (central office, switching, etc..) the shorter the section length will be to accommodate the more numerous splice and branch points from the main distribution line.
- B.) The location where the main distribution line and network interfaces with feeder cables and the number of access points along the feeder for customer connections.
- C.) The maximum size of cable reel lengths for the cable being placed.
- D.) Maximum allowable pulling tension for the cable.
- E.) Physical obstructions to manholes and handholes such as described in list item #2 above that may require additional bends, directional and changes in pitch to avoid obstructions.
- F.) Safe manhole, handhole, and pullhole environment such as noted above in the list item #3 above.

### 23.8.1 Pulling Tension

There are fundamental limits to the amount of tension that can be used to pull cables into a length of conduit. The required pulling tension is determined by the weight of the cable, the coefficient of friction of the conduit or duct, and the geometry of the conduit/duct run (bends and changes in pitch along the run).

Basic design coefficients of friction for several general types of conduit material are listed below in the table for a traditional polyethylene sheath with/without standard lubricants in various duct or conduit materials.

Modern designs of conduit, duct and microducts have included serrated interior surfaces, modified coatings and other strategies to reduce the coefficient of friction from these baseline values.



Newer formulations for cable jacket materials and cable designs can also contribute to reducing the coefficient of friction and increase the pulling lengths for a given maximum pulling tension. The basic equation for the pulling tension (T) in pounds (lb) in a straight segment of duct is given by:

$$T = T_o + f \times W \times S$$

where:

$T_o$  = back tension (lb) at reel

$f$  = coefficient of friction

$W$  = unit weight of cable in pounds per foot (lb/ft)

$S$  = length of segment (feet)

**Table 23-1 Design Coefficients of Friction**

| Duct Material | Polyethylene Cable Sheath |                  |             |
|---------------|---------------------------|------------------|-------------|
|               | No Lubricant              | B or C Lubricant | D Lubricant |
| Concrete      | 0.60                      | 0.42             | 0.25        |
| Fiber         | 0.47                      | 0.44             | 0.25        |
| Fiber-Cement  | 0.50                      | 0.50             | 0.25        |
| Plastic       | 0.43                      | 0.38             | 0.18        |

However, such straight flat conduit/duct runs are idealistic situations and accommodation needs to be made for necessary bends and changes in direction (pitch and bend) of the real-world cable run.

To find the pulling tension needed for a conduit section containing both straight and curved segments, the engineer calculates the tension segment-by-segment, starting at the feed (or reel) end.  $T_o$  is the tail load on the cable entering the duct. Use the calculated value of  $T$  found for the first segment as  $T_o$  for the second segment, and so on, until the pulling tension on the cable at the winch is obtained.

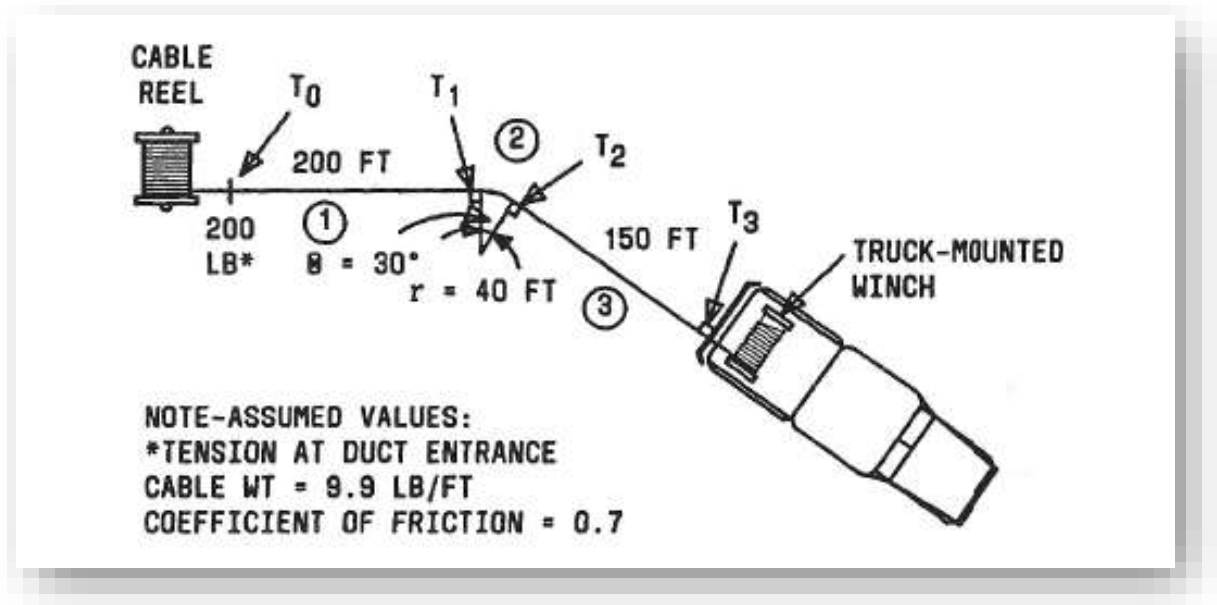
To illustrate the process of calculating the pulling tension, one can take a sample pull as shown in the schematic (Figure 23-1) and apply the above analysis procedure to the pull to obtain the results shown in Table 23-2 using alignment chart shown in Figure 23-2 below. For this illustration, the problem would be solved in three steps:

1. Calculate pulling tension  $T_1$  at the end of the first (straight) section, using the  $T_o + FWS$  formula.



2. Use the  $T_1$  calculated in Step 1 above as  $T_0$  for the second curved section where the alignment chart to find the pulling tension  $T_2$  at the end of the second (curved) section.
3. Use the second result ( $T_2$ ) as  $T_0$  for the 3<sup>rd</sup> straight line section to calculate the pulling tension  $T_3$  at the end of the 3<sup>rd</sup> (straight) section.

**Figure 23-1 Schematic of Cable Pull for Illustration Purposes**



For the Straight Sections use the formula  $T_0 + w(f \cdot X \pm h) = T$  (Tension) to determine the pulling tension required to get the cable to the end of section.

For the Curved Sections use the alignment chart (Figure 23-2) to determine  $T/Wr$  values based on values of coefficient of friction ( $f$ ), angle of bend ( $\theta$ ) and calculated value of  $T_0/Wr$  at the beginning of the curved section.

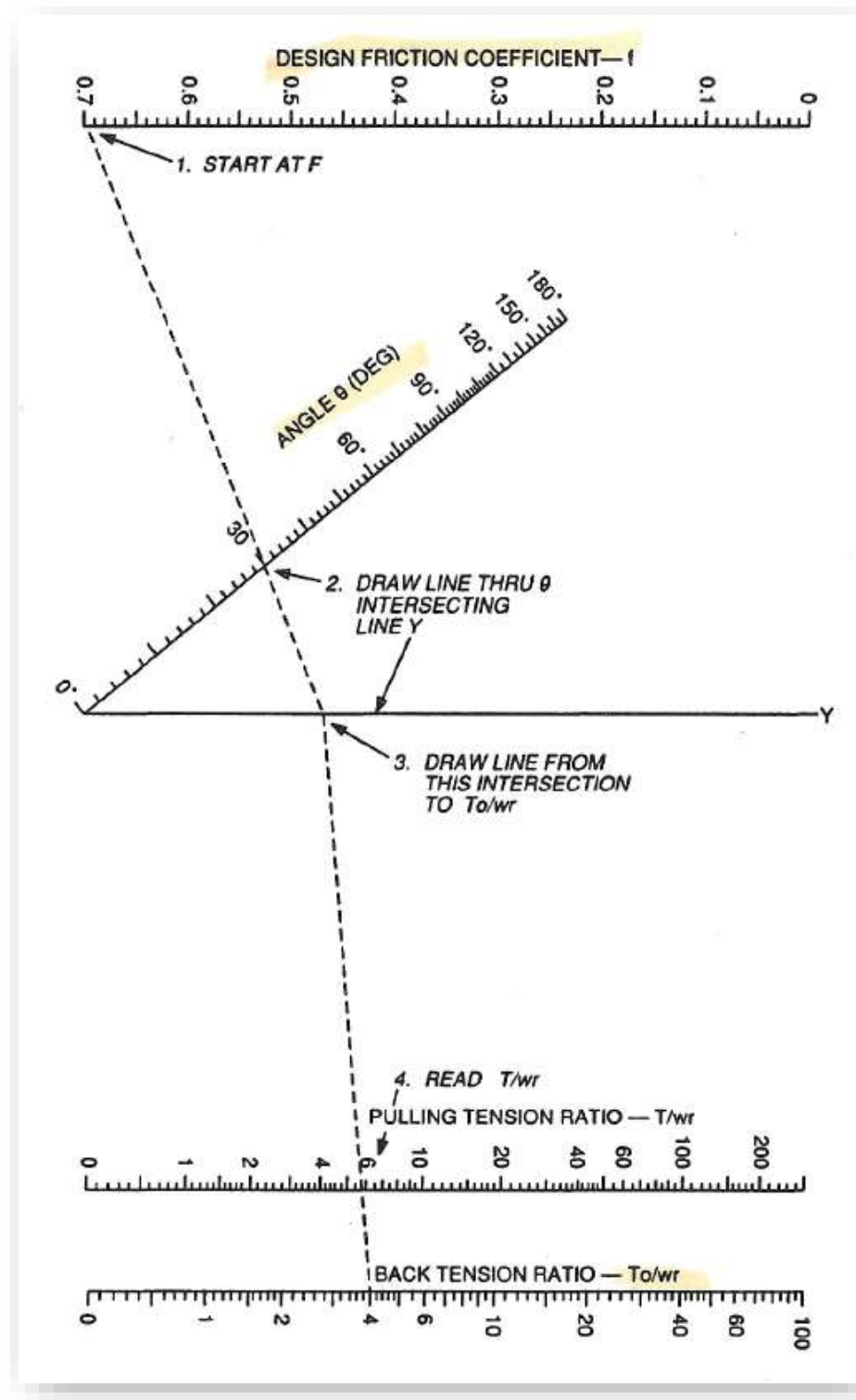
**Table 23-2 Key Parameters for Tension Calculations**

| Key Parameters                                      |                                        |
|-----------------------------------------------------|----------------------------------------|
| $T_0$ = Back Tension (Hold Back Tension)            | $f$ = coefficient of friction          |
| $T$ = Tension Force (lbs)                           | $W$ = weight per foot of cable         |
| $T_0/Wr$ = Back Tension Ratio                       | $S$ = length of segment                |
| $T/Wr$ = Pulling Tension Ratio from Alignment Chart | $X$ = horizontal projection of Segment |
|                                                     | $h$ = vertical projection of Segment   |
|                                                     | $r$ = radius of curved section (ft)    |
|                                                     | $\theta$ = angle in degrees            |

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Figure 23-2 Alignment Chart for Curved Section Calculations



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**Table 23-3 Tension Calculation for Illustrated Pull Case in Figure 23-1**

| Segment                                                      | Straight Section                |                           |      | Curved Section                                                                                                                          |                                 |      | Total Tension (lbs)    |
|--------------------------------------------------------------|---------------------------------|---------------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------|------------------------|
|                                                              | $T_0 + W (f \cdot X \pm h) = T$ |                           |      | $T_0 / (W \cdot r)$                                                                                                                     | $(T/Wr) \times (W \cdot r) = T$ |      |                        |
|                                                              | $T_0$                           | $+ W (f \cdot X \pm h) =$ | $T$  |                                                                                                                                         |                                 |      |                        |
| 1                                                            | 200                             | $9.8 (0.7 \cdot 200) =$   | 1590 |                                                                                                                                         |                                 |      | 1590 (T <sub>1</sub> ) |
| T <sub>1</sub> from Step 1 becomes T <sub>0</sub> for Step 2 |                                 |                           |      |                                                                                                                                         |                                 |      |                        |
| 2                                                            | 1590                            |                           |      | f = 0.7 and $\Theta = 30$ degree and T <sub>0</sub> /Wr value are entered into the above alignment chart to read a value of T/Wr of 5.8 |                                 |      |                        |
|                                                              |                                 |                           |      | $1590 / (9.9 \cdot 40) = 4.0$                                                                                                           | $5.8 \times (9.9 \cdot 40) =$   | 2300 | 2300 (T <sub>2</sub> ) |
| T <sub>2</sub> from Step 2 becomes T <sub>0</sub> for Step 3 |                                 |                           |      |                                                                                                                                         |                                 |      |                        |
| 3                                                            | 2300                            | $9.8 (0.7 \cdot 150) =$   | 3340 |                                                                                                                                         |                                 |      | 3340 (T <sub>3</sub> ) |

If the required or expected pulling tension from the calculation exceeds the pulling strength of the cable to be placed, then the placement procedure will need to be revised by adding an intermediate pull box, starting in middle of run and pull in both directions (also known as back-feeding), providing a manual assist at the intermediate handhole to lower tension, modifying the lubricant or internal duct surface to decrease friction, or change the placement procedure entirely from a pulling method to one using a high-speed air blowing technique (HASB) described in Chapter 22.

**Note:** Back-feeding is a term used to describe a procedure in which the cable is spooled off a partially empty cable reel (after the leading end of the cable has been pulled into the underground plant), stored on the ground in a figure-eight coil at the cable feed point, and pulled into the underground plant in a direction opposite to the initial pull. This technique is appropriate when pulling for the full cable reel length would result in too high a tension being placed on the cable.

For multi-twisted pair cables the maximum cable pulling tensions can range from 400 to 6000 lbs as illustrated below -

- 400 lbs for a 100-pair 26AWG cable
- 600 lbs for a 100-pair 24AWG cable
- 1000 lbs for a 100-pair 22AWG cable
- 5400 lbs for a 1500-pair 26AWG cable
- 6000 lbs for a 600-pair 22 AWG cable or for 300-pair 19AWG cable

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The maximum pulling strengths for distribution coaxial cables (hardline) and optical

fiber cables are usually around 300-600 lbs. The uniform concentric design of inner and outer conductors in the distribution hardline coaxial cable is critical to maintaining the transmission power and quality of coaxial cables. Overstressing the coaxial cable during placement can flatten the outside conductor.

Overstressing of optical fiber cable during placement can transfer mechanical stress into the cable core and onto the optical fibers therein which can result in fracture of the fibers and/or surface damage to the fiber that leads to premature degradation of optical transmission and increased optical losses. The twisted-pair copper pairs are more robust under such mechanical stresses.

The maximum pulling tensions specified by the cable manufacturer should never be exceeded otherwise the cable is likely to be damaged. Breakaway swivels are employed to help ensure such pulling tensions are not exceeded. The typical procedure is to choose a breakaway swivel with a release point 10% lower than the maximum cable pulling tension, or less.

When optical fiber cable placement was expanding and concerns of possible transfer of mechanical stress during a cable pull into the cable core initiated several engineering studies into efficient cable pulling techniques for optical fiber cables. These studies were focused on working out strategies for placing long conduit runs of long distance intercity fiber cable runs safely and efficiently.

### 23.8.2 Optical Fiber Cable Case Studies

Optical fiber cable will usually be pulled into an innerduct liner or conduit which may be a smooth bore or a corrugated liner. The typical coefficient of friction for pulling lubricated cable into smooth bore is 0.25 and 0.20 for a corrugated duct liner. Such suitable liners are recommended to maximize the length of optical fiber cable that can be placed in a single pull. In general it is recommended that three duct liners be the maximum number placed in a 3-1/2 or 4-inch diameter conduit/duct where long cable pulls are to be made otherwise the effective coefficient of friction will increase

The tensile load rating specified (by the manufacturer) for optical fiber cable is the limiting tensile force to which the cable can be subjected without risking fiber damage. Although the tensile force in a cable being installed cannot be predicted precisely, an estimate must be made in order to plan the location of each cable splice and maximum pulling distances.

The maximum pulling distance varies in inverse proportion to the friction coefficient. The actual bends, curves and changes of direction of a conduit run can be usefully modeled by assuming a continuous large radius curve.

Studies by AT&T Bell Laboratories have found that using a duct curvature of *160 degrees per 1000 feet* accounts well for the plan and profile bends as well as construction irregularities for runs. That work developed an empirical algorithm for pulling tensions and estimates of maximum pulling distances of optical cables through innerducts in underground conduit systems based on the following equation.

$$T/W = 127 \cosh (f \times L/360) + 382 \sinh (f \times L/360)$$

where,  $f$  = coefficient of friction

$L$  = distance cable is pulled in feet

$W$  = unit weight of cable in pounds per foot (lb/ft)

$T$  = Tension Force in pounds (lbs)

This algorithm assumes that (1) the cable reel is attended to help ensure the tail load remains near to zero during the pulling operation, and (2) there are no large or sharp bends in the conduit run. The "*160 degrees per 1000 feet*" constant accounts for the normal expected perturbations in a conduit run such as the up/down pitches of the conduit between manholes, necessary bends in manholes/handholes where ducts are offset on opposite walls, and the general accumulation of duct curvature as the duct/conduit moves to left, right, up or down depending on soil conditions and soil settling that may occur along the run.

If deliberate large bends and deviations in the conduit run are required to avoid obstructions or maneuver around other underground facilities or roadwork for example, then the angle and length of such conduit deviations need to be determined or estimated so that the step tension calculations (see previous section and Table 23-3 above) can be made.

The guidance chart below (Figure 23-3) shows the relationships between cable tension and pulling distance. The key parameter ratio " $T/W$ " is the peak tensile force in the cable divided by the unit weight per foot. " $L$ " is the pulling distance in feet, and " $f$ " is the coefficient of friction. For this particular illustrative set of curves in the chart, a coefficient of friction of 0.20 can be used for corrugated polyvinyl chloride (PVC) duct liner and corrugated polyethylene duct liner, assuming that the cable and pulling line are well lubricated during the placing operation. For new smooth wall PVC pipe (lubricated), 0.20 should be used as a coefficient of friction.

If pulling into shorter sections of unlubricated new PVC duct or duct liner or polyethylene duct liner, such as for building entrance back-feeds, a higher 0.30-0.35 coefficient of friction should be used. If cable must be pulled into

an existing older duct without an innerduct a conservative value of 0.45 coefficient of friction should be used.

Based on the algorithm, placing practices were developed with several graphical methods and engineering guides for designer and construction crews to plan and install fiber cable in long underground conduits. To engineer the appropriate underground pulling lengths, one can use the graphs shown below (Figure 23-4 and 23-5) as follows:

- The maximum cable's tensile rating and unit weight per foot, "T/W" can be calculated, or are known, and a horizontal line drawn at that level on these charts.
- Where the line intersects the applicable coefficient of friction curve, the limiting pulling distance can be read directly below on the horizontal scale. If the planned pulling length in question is shorter than the limited pulling distance, the pull is acceptable.

An alternate approach would be to select a desired pulling distance, draw a vertical line to the coefficient of friction curve, and then move horizontally to a "T/W" ratio on the vertical scale. By multiplying this ratio by the weight per foot of the cable, a pulling tension estimate can be obtained.

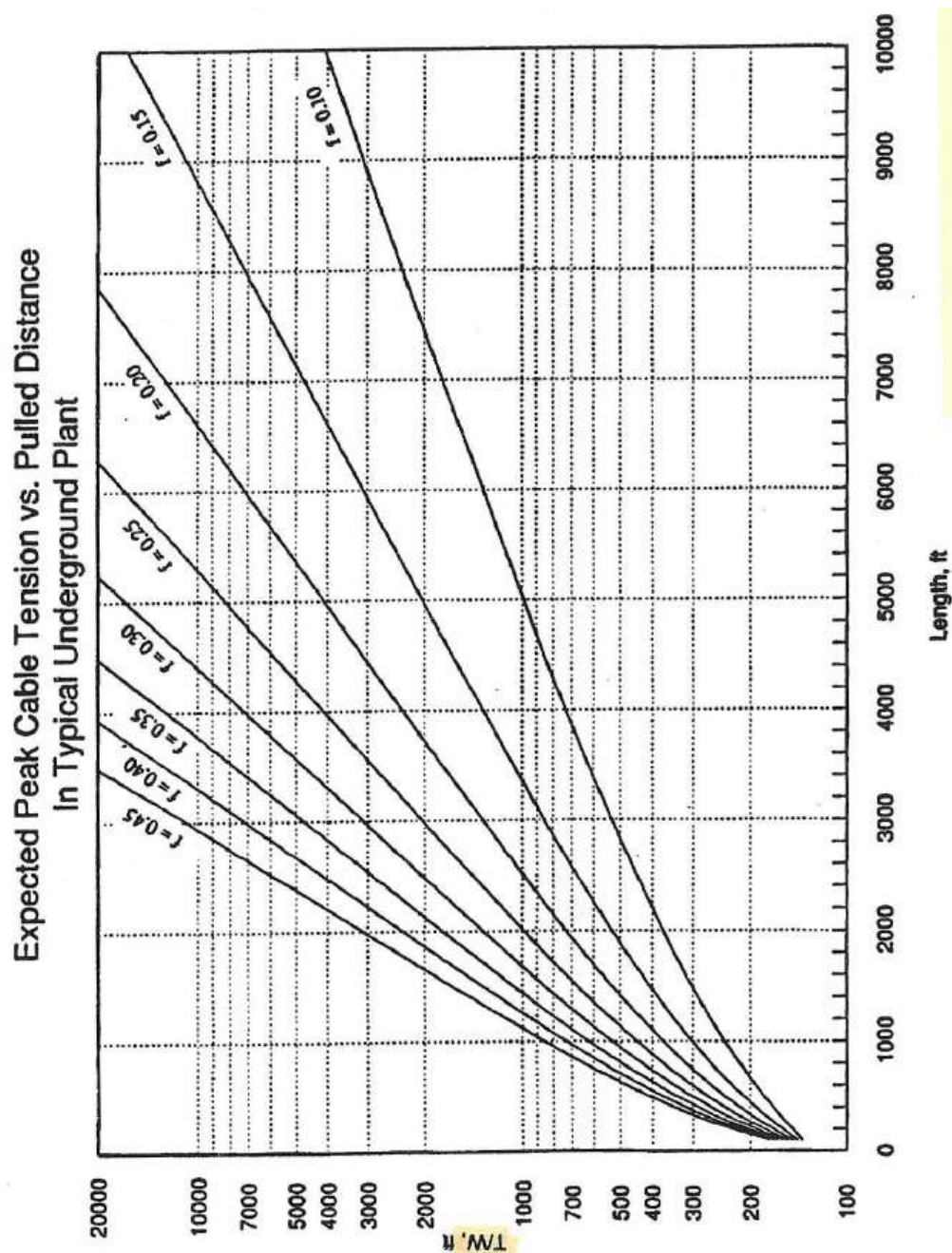
For any final pulling estimates, one will need to adjust for large or sharp bends and transitions in the manhole or along the conduit run. For example, each time the cable is to be pulled through a severe transition curve, such as a 90-degree turn at a "T" or "J" manhole, 500 feet (152 m) should be subtracted from the pulling distance. A second common case occurs in a pull-through manhole where entry and exit ducts are offset by distances greater than one-half the manhole length. For such an offset condition, an additional 500 feet (152 m) should be subtracted for each case.

In summary, these general caveats and adjustments apply to the use of these graphs are -

Caveat 1. When computing the maximum pulling length, subtract 500 feet from the length for each 90 degree bend in the pulling section of the run or at the manhole/handhole.

Caveat 2. When computing the maximum pulling tension for optical fiber cables, add 500 feet to the length for each 90 degree bend in the pulling section of the run or at the manhole/handhole.



**Figure 23-3 Peak Cable Tension versus Pulled Distance - Optical Fiber Cable**( Series of curves for coefficient of friction ( $f$ ) values 0.10 to 0.45)

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Figure 23-4 (below) illustrates the calculation for the maximum pulling distance for a sample of 6000 foot reel of optical fiber cable with a unit weight (W) of 0.085 lb per foot and a tensile strength limit of 600 lb. The value of the T/W calculated from these cable characteristics is

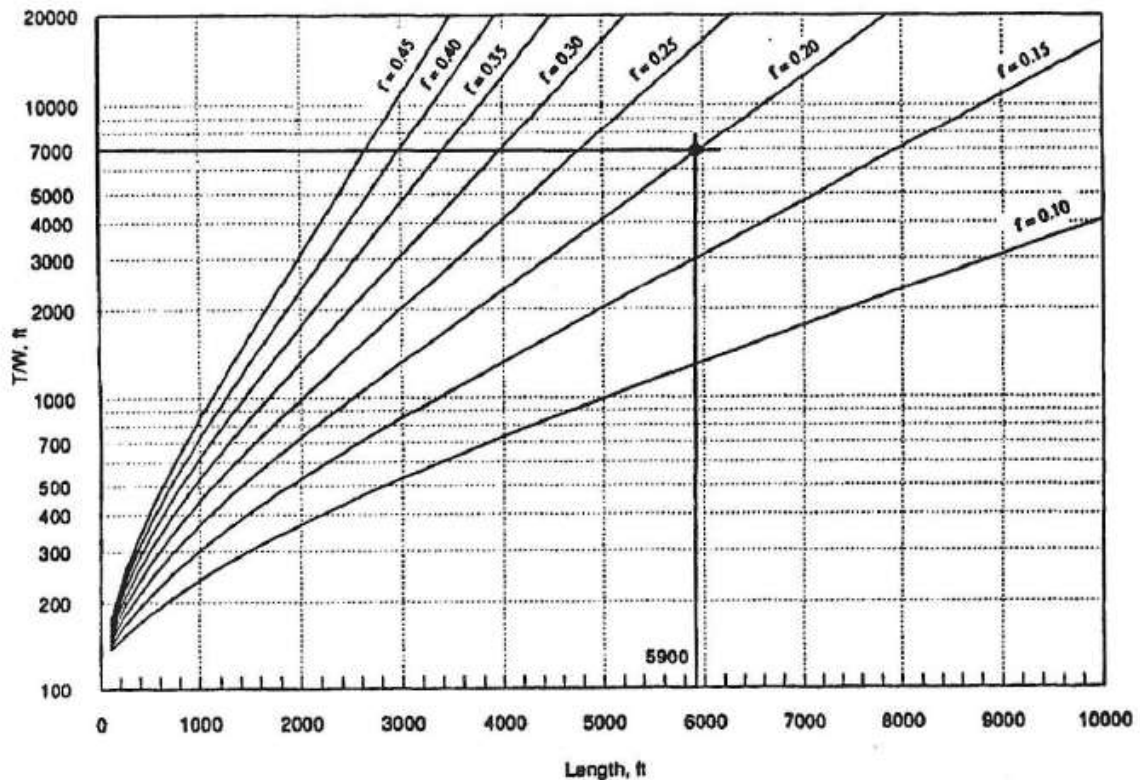
$$T / W = (600 \text{ lb}) / (0.085 \text{ lb/ft}) = \text{equals } 7059 \text{ ft}$$

which would be rounded off to 7000 feet.

From Figure 4 for this T/W value the maximum allowable pulling distance in a new lubricated PVC conduit (i.e.,  $f = 0.2$ ) would be 5900 feet.

If the measured distance between manholes was measured at 5000 feet and the course of the pull involved one midspan 90-degree "J-type" manhole and two pull-throughs with severe duct offset, the calculated pulling distance should be reduced from 5900 by three 500 feet increments to 4400 feet (in accordance with the caveats above). In this case, a figure-eight back-feed would be needed in order to successfully place the cable.

**Figure 23-4 Illustration of Maximum Pulling Distance**



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Longer placements are possible through modifying various factors designed to reduce the pulling forces by reducing friction and thereby maximize possible pull lengths while staying well under the desired pull strength of the cable -

Keep cable runs as straight as practical - minimize bends or make them as large a radius as possible and practical.

- Use lubricants to reduce friction.
- Modify the internal surface design (shape and/or coating material) of the conduit to reduce friction.
- Use larger conduits and/or smaller fiber cables to reduce frictional forces.
- Use air-blowing systems to float and/or blow cable through conduit rather than pull it through the run.

If the traditional pulling methods cannot be used to meet the distance requirements, alternate placement technique can be used including HASB (High-Air-Speed Blown-Cable system) techniques which are often preferred since it removes the tensile stress that may occur during pulling cables (see Chapter 22 ). The conduit system needs to be reasonably air-tight so the air pressure is maintained throughout the run. Often older conduit runs may have too many leaks to be effectively cable pathways for the HASB techniques.

HASB jetting techniques can routinely place cables distances of 2,500-3,000 ft with longer distances possible (e.g., more than 6,000 feet) in favorable circumstances such as small light weight micro-optical fiber cables through microducts designed with low-friction internal surfaces as well as use of new lubricant materials to maximize placement distances.

## 23.9 Informative References Related to Direct-Buried Applications

For more detailed functional performance requirements of innerduct and conduit, consult the following references:

1. GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit, and Accessories*.
2. Bellcore CA0-8546, *B, C, and D Plastic Conduit*.
3. ASTM D2122, *Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings*.
4. ASTM D2239, *Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter*.
5. ASTM D3035, *Standard Specification for Polyethylene (PE) Plastic Pipe (DRPR) Based on Controlled Outside Diameter*.
6. Bell System Practice, BR-920-400-200, *Light-guide Cable - Installation Planning - Buried* (Issue 2, 1982).
7. Telcordia (Bellcore) Practice BR-629-300-215, *Buried Plant - Plowing* (Issue 3, 1984).
8. AT&T Practice 919-240-001 – Conduit Planning and Design Guidelines
9. AT&T Practice 919-240-100 - Factors Affecting Section Lengths of Conduit, Conduit Curve Design and Pulling tensions
10. AT&T Practice 919-240-200 – Conduit Sizing
11. AT&T Practice 628-200-215 & -216 - Pulling tensions for Optical Fiber Cable
12. AT&T Practice 628-200-208 – Underground Cable Placing
13. Telcordia (Bellcore) Practice BR 629-100-010 – Buried Plant: Precautions and Maintenance to Existing Systems
14. Bell System Practice BSP-919-240-100 – Conduit System Design
15. Bell System Practice BSP-919-240-200 – Conduit Structure Sizing
16. Bell System Practice BSP-919-240-400 – Underground Conduit Materials – Types and Fields of Use
17. Bell System Practice BSP-920-400-100 - Lightguide Cable (Optical Fiber Cable) – Installation Planning - Underground
18. Bell System Practice BSP 920-400-200 - Lightguide Cable (Optical Fiber Cable) – Installation Planning - Buried.

## 24 Horizontal Directional Drilling (HDD)

### 24.1 General

The technique of Horizontal Directional Drilling (HDD) has developed rapidly over the last decade for applications within the telecommunications industry and is now commonly referred to as the “trenchless technology” for placing utility lines below ground. The equipment and procedures are intended to minimize surface damage, restoration requirements and traffic disruption, with little or no interruption of existing services. Although originally developed by the power industry, the telecommunications industry represents the largest single industry segment to use the various types of HDD for placing or replacing its buried facilities.

HDD procedures are typically performed by contractors and their personnel who have the requisite skill and training, as well as extensive on-the-job experience. Nonetheless, as the owner of the facilities, it is important that a communications company have a good understanding of the relevant HDD procedures and practices. As described below, a communications company can significantly contribute to the efficiency and success of a large-scale HDD operation by appropriate participation in the planning and preliminary stages. It is also important that the communications company inspectors have sufficient knowledge to help ensure that its lines are placed correctly.

Issues of concern include the reliability of the installed product (duct, cable), customer relations and safety, as well as possible environmental issues. Note that NESC Rule 410C requires that the employer provide a designated (qualified) person as an inspector to be in charge of the operation and equipment and have the responsibility for its safe operation. This chapter provides basic HDD information and brief guidelines but does not replace the need for an industry-provided “HDD Inspector Training and Certification” course that lasts several days. Separate, more extensive courses are provided for HDD contractors and their operators and personnel by industry and research groups such as the Michigan State University Center for Underground Infrastructure Research and Education (CUIRE), East Lansing, MI.

The information in this section is consistent with generally recommended and accepted industry practices for HDD such as:

- IEEE 1333, *IEEE Guide for Installation of Cable Using the Guided Boring Method*.

**Note:** Although officially withdrawn as a standard, this 1994 guidance document is still available from IEEE and contains useful guidance material.

- *Horizontal Directional Drilling Guide*, North American Society for Trenchless Technology (2022) - A Comprehensive Look at the North American HDD Industry (<https://trenchlesstechnology.com/hdd-guide/>)

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- TR-46, *Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe*. (Plastics Pipe Institute - [http:// plasticpipe.org](http://plasticpipe.org)), 2009.

## 24.2 Description

Horizontal directional drilling installs pipes or utility lines below ground using a surface-mounted drill rig that launches and places a drill string at a shallow angle to the surface and has tracking and steering capabilities. Mini-horizontal directional drilling (or mini-HDD, also known as “guided boring”) is typically used for the relatively shorter distances and smaller diameter “product pipes” associated with local distribution lines, in comparison to maxi-horizontal directional drilling, typically used for longer distances and larger diameter products, such as major river crossings. “Medi-horizontal” directional drilling is an intermediate category that may be used for appropriately sized HDD projects. Although there are many similarities among the various categories, this section focuses on mini-HDD type applications, such as for the local distribution of buried plant. Mini-HDD may typically be used for boring holes of up to several hundred feet in length and placing an individual or bundle of “product pipes” of less than 10 inches total diameter, at depths less than 15 feet.



The mini-HDD drill rig creates a pilot bore hole in an essentially horizontal path or shallow arc that may subsequently be enlarged to a larger diameter

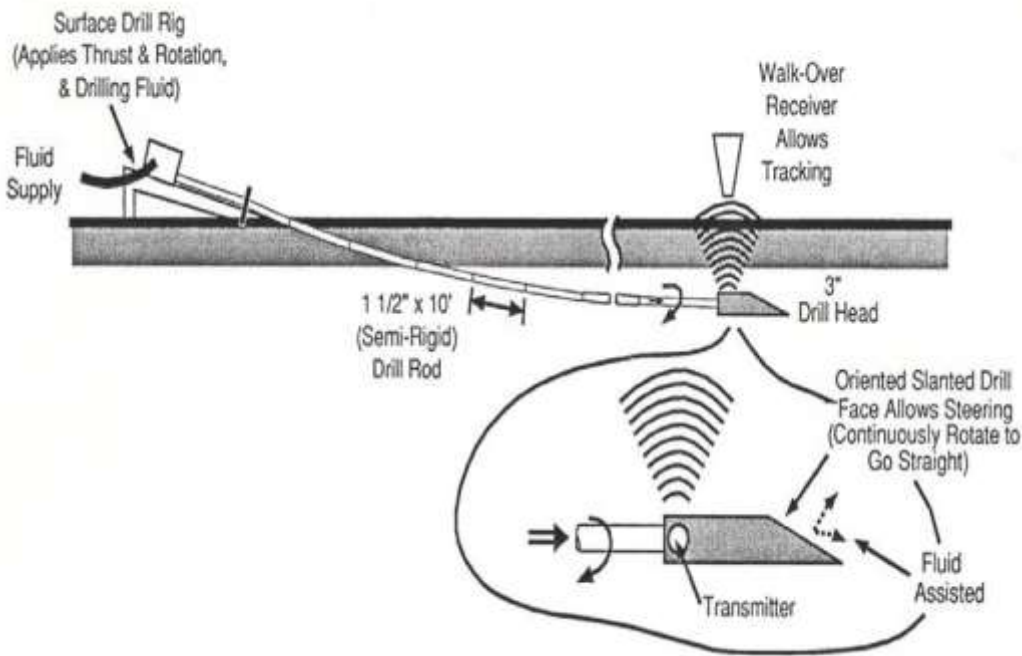
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during a secondary operation, which typically includes reaming and pullback of the product pipe or utility line. [Figure 24-1](#) and [Figure 24-2](#)

**Figure 24-1 Mini-HDD, Initial Pilot Hole Boring Process**



illustrate these two stages of the typical mini-HDD process.

The creation of the pilot bore hole and the reaming operations are typically accomplished by fluid jet cutting and/or mechanical cutting torque provided by rotating the drill head. The procedure typically uses a high-pressure, but low- controlled volume of drilling fluid flow to minimize the creation of large voids during the initial boring or subsequent back-reaming operations. The drilling fluid helps stabilize the bore hole, remove cuttings, provide lubricant for the drill string and product pipe, and cool the drill head. The resultant slurry surrounds the product pipe, typically filling the annulus between the pipe and the bored cavity and providing a permanent supportive filling. In some cases, such as in hard or rocky soil conditions, “mud motors” powered by the drilling fluid may be used. The use of such mud motors would only be applicable for the larger mini-HDD (or medi-HDD) machines.

Tracking of the initial pilot bore path is accomplished by a manually operated overhead (walkover) receiver or a wireline guidance (non-walkover) tracking system. The walkover system ([Figure 24-1](#)) is more common, for which the receiver is placed above the general vicinity of the drill head to allow a determination of its location and depth, and to indicate drill head



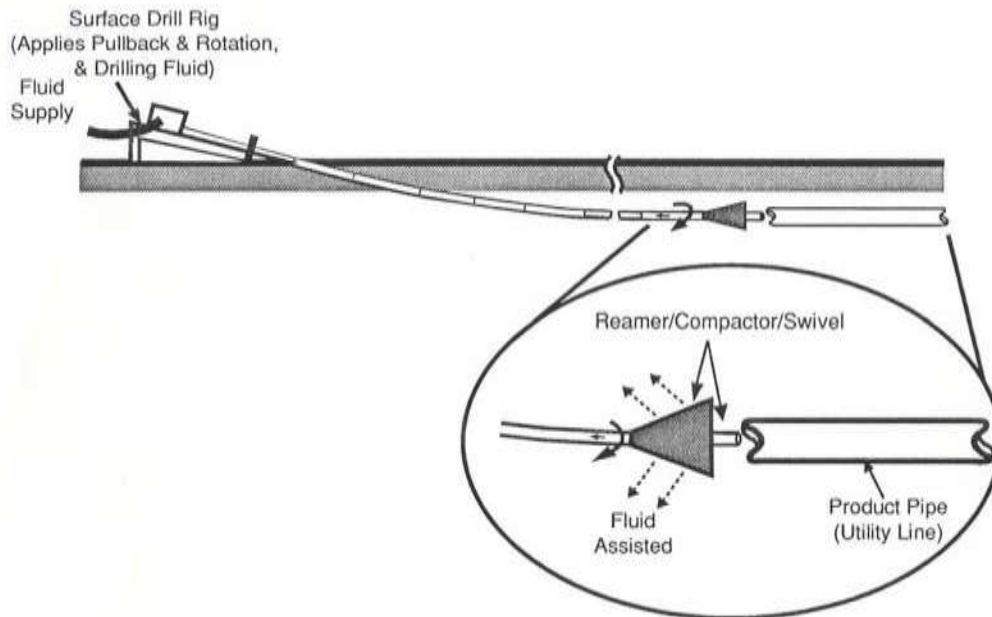
orientation for determining steering information to be implemented from the drill rig. The information is relayed to the drill-rig operator by direct communications from the tracker, or possibly by means of a remote transmitter. Steering is achieved by controlling the orientation of the drill head, which has a directional bias, and pushing the drill string forward with the drill head oriented in the direction desired. Continuous rotation of the drill string allows the drill head to bore a straight path.

For typical communications applications, the product pipe(s) indicated in [Figure 24- 2](#) would be High-Density Polyethylene (HDPE) innerduct, such as described in [Chapter 23](#). Either a single innerduct or a bundle of HDPE innerducts may be placed.<sup>2</sup> The desired communications cable (fiber, coaxial, or copper) may subsequently be installed in the innerduct path, as convenient. Although it is possible to directly connect the exposed cable to the swivel for pulling into the hole, such a procedure is not recommended for most cables unless special protection (armor) is provided.

**Note:** Some techniques using fusible PVC Schedule 40 conduits have also been used successfully

**Note:** The direct pullback of a fiber or coaxial cable, without special protection, is not recommended because of the risk of physical damage to the cable.

**Figure 24-2 Mini-HDD, Backreaming/Pullback Process**



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## 24.3 Preliminary Site Investigation

The feasibility and desirability of using mini-HDD for a particular project depends upon many factors, including soil conditions, location of other utilities, environmental aspects, and particular features and characteristics of the existing area. Any pollutants or contaminants in the construction area must be identified, and spoil disposal arrangements must be considered. The size and anticipated duration of the project and the existence of other reasonable alternatives are important considerations. A mini-HDD project may be a brief undertaking, lasting only a matter of days to perform an isolated task on the order of several hundred feet, such as a road crossing or the replacement of a damaged communications cable, or a large-scale upgrade of degraded distribution lines serving an entire community, and requiring the replacement of tens to hundreds of thousands of feet. Such a large-scale project may require months or years to complete.

In general, various aspects of the preliminary site investigation may be performed by a communications company or their contractor, or both. The communications company may elect to conduct a background study to provide information to the contractors to serve as a basis for a meaningful and equitable bidding process. The contractors may desire to conduct additional investigations in preparation for bid submittal as well as to provide guidance for the actual construction following awarding of contracts.

### 24.3.1 Existing Below-Ground Utilities

Since mini-HDD projects typically consist of installing new lines in established areas with an existing network of other utilities, a minimal requirement is an understanding of the type and general locations (including depths) of these networks to avoid potential damage and to guide the more detailed inspections required during the actual construction stage. The new distribution lines will generally be placed along the main Right-of-Way (ROW), and associated service lines (drops) will be installed laterally beneath the individual properties. Existing utilities within the ROW will determine the available area for placing the new distribution lines. The depths of the existing laterals may affect the depth of the new lines which must cross these service lines at individual residences or structures.

In addition to the utility service lines to the individual structures, the general presence and frequency of privately installed electric or lawn sprinkler lines within individual lots should be considered.

### 24.3.2 Surface Investigation

Any contractor(s) should take into consideration the required work areas based upon accessibility, rig set-up, and pipe prefabrication if continuous pipe (innerduct) is not supplied on a reel. The drill-rig working areas should be reasonably firm, level,

and suitable for the movement of rubber tires or tracks. A total area of approximately 40 feet × 15 feet is required. However, associated trailers containing drilling fluids, pumps, hydraulics, etc., need not be in the immediate vicinity. The communications company should determine and specify the typical innerduct route

and architecture required, including the number and size of innerduct paths required, and their termination points.

Although remote (non-walkover) tracking systems are available, potential bore routes should ideally allow the locator to be placed above the bore path for monitoring the progress of the drill head. Overhead structures or wire lines represent potential problems in moving equipment, or possible sources of interference to the electronic locators of mini-HDD tracking systems. Steel-reinforced concrete sidewalks, driveways, and roads also represent potential problems for locators.

A source of water, preferably potable, must be available to mix any required drilling fluids. In general, drilling fluids are not considered hazardous materials. However, an acceptable means to dispose of excess drilling fluids must be identified and consistent with local regulations.

Although noise levels associated with mini-HDD equipment are generally not excessive, there may be restrictions on work hours in areas near residential buildings, hospitals, or other institutions.

### 24.3.3 Subsurface Investigation

The effectiveness of any buried construction method is strongly dependent on the subsurface conditions. This is especially the case for trenchless techniques, which are typically less aggressive than conventional open-cut trenching methods, or require steering and maneuvering below ground. It is therefore important to perform an investigation to understand the local soil characteristics and ground conditions, including potential obstacles. Such a study will reduce uncertainty and result in more realistic cost estimates and help verify the general feasibility of the project. It should be noted, however, that most mini-HDD projects involve pipe placements within only 6 feet of the surface, and in established areas. Therefore, the relevant conditions are not necessarily that of virgin soil at greater depths, but may be that of disturbed or filled areas, possibly including man-made debris or obstacles. It is recommended that the communications company or its representative



(e.g., a geotechnical engineer) perform such an overall investigation, the results of which should be provided to potential contractors. The contractor(s) may elect to perform additional studies, as desired, before or after the awarding of contracts.

The extent of the investigation should reflect the magnitude of the project. However, it may not be practical to characterize in detail all the areas involved in a large-scale mini-HDD project involving high cumulative footage and covering a large area. The investigation should include a review of published soil reports (e.g., state or county soil conservation service reports, U. S. Geographic Survey, or U. S. Army Corps of Engineers reports) or local records from previous construction projects in the vicinity. The study should attempt to reveal the presence of below-ground structures, including those that may have been abandoned. Construction information from previous projects involving trenchless methods would be most relevant, if available from other utilities or owners.

## 24.4 Safety During HDD Operation

Injury to personnel may result directly from the mechanical and hydraulic machine operations or may be caused by damage to working or powered subsurface facilities during the initial boring or backreaming operations. Thus, the important damage prevention procedures outlined in [Section 24.6](#) to avoid impacting customer services are also essential with regard to personal safety. Compromising the outer protective sheath of an electric power cable or natural gas line by a drill head or backreamer creates an immediate danger to all personnel and individuals in the vicinity. Damage to a pipe transporting petroleum or hazardous materials represents a danger to the personnel as well as an environmental problem requiring immediate cleanup. Non-essential personnel and bystanders should not be allowed in the immediate vicinity of the mini-HDD equipment. Barriers and warnings should be placed a minimum of 6 feet from the edge of the equipment or associated hardware. In general, safety precautions are to be followed by all personnel, and along the entire bore path.

Adequate vehicular control and flow, including the use of flagmen, should be maintained to minimize disruptions to traffic. Warning lights and traffic cones must be used to ensure a safe working environment for the construction personnel as well as non-construction related passersby.

Depending on the size, depth and soil type, pits will be needed during preparation phases and during the mini-HDD operation for the purposes of utility terminations, collecting drilling fluid, exposing other utilities at drill path crossings, and clearing blockages, etc. These pits may require shoring, and all local regulations and utility construction requirements should be observed.

All personnel in the vicinity of the drill rig, or at the opposite end of the bore, should be properly trained and educated regarding the potential hazards associated with the mini-HDD equipment, safe operating procedures, safety equipment, and proper precautions. Courses and seminars are available in the industry, including training provided by the equipment suppliers. For example, all personnel should be familiar with OSHA 3075, and have First Aid and CPR training.

---

**! CAUTION !** *Personal Protection: Mini-HDD Operators should not wear loose clothing or jewelry since they may snag on moving mechanical parts.*

*Safety glasses or OSHA- approved goggles, or both, and OSHA-approved head gear (hard hats) should be worn at all times.*

*Electrical insulating boots and gloves must be worn by all personnel to guard against electrical shock in the event of inadvertent contact with a power line.*

*These protective items should be regularly inspected, cleaned, and maintained to preserve their insulating properties.*

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Contractors must comply with all applicable OSHA, state and local regulations, and accepted industry practices. The operation of the drill rig requires rotation and advancement or retraction of the drill rods, and is typically accomplished using chain drives, gear systems, and vises which may offer an opportunity for personal injury due to the moving mechanical components. All safety shields or guards must be properly mounted. The equipment must be checked at the beginning of each work day to verify proper operation.

The hydraulic oil lines powering the drill rig operate under pressures of several thousand psi (hundreds of bars). The hoses and connectors must be properly maintained to minimize leaks.

Drilling fluid pressures will vary depending upon the equipment design and operator preference; pressures of several thousand psi (hundreds of bars) are possible. The hoses and connections must be properly maintained to minimize leaks.

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**! CAUTION !** *Leak Detection: If a leak is suspected, it should be checked by using a piece of cardboard or other object, but not by using hands or any other part of the body. The high pressure hydraulic fluid can penetrate the skin, burn, or cause blood poisoning. Before disconnecting any hydraulic lines, the system pressure should be relieved.*

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**! CAUTION ! Fluid Pressure:** Before inserting or removing individual drill rods from the drill string, the **drilling fluid pressure must be shut off and allowed to decrease** or high pressure fluid will squirt from the joint and possibly cause injury to personnel. The drilling fluid pressure gauge must be checked to verify the pressure has been relieved before disconnecting any rods.

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**Note:** If the pressure does not decrease in a short interval following pressure shut off, the fluid jet openings of the drill head may be clogged. Special care must then be taken when disconnecting the rod. It may be necessary to retract the drill string or expose the drill head to clear the jets before continuing the operation.

All personnel should maintain a safe distance from the exit point of the bore as the drill head surfaces, to avoid injury from the drill head and drilling fluid. The pressure should be shut off as soon as the drill head exits.

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**! CAUTION ! Electrical Safety:** To reduce the risk of injury to personnel, an **electrical strike safety system must be used**. Such systems include proper clothing (described above), grid mat system, ground rod, barriers, electrical strike sensing system, and proper electric bonding hardware for connecting the appropriate components. The proper operation of the sensing system should be checked for proper operation in advance of construction each day.

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Once the drill head exits at the far end of the bore, a backreamer is usually attached to expand the diameter of the hole, to allow a bundle of individual innerducts to be pulled back into the hole. The larger diameter backreamer may not be necessary if only a single innerduct is to be placed. In some cases, e.g., for a very large bundle of innerducts, a “pre-reaming” operation may be required prior to the final backreaming step during which the product pipes are installed. In a pre-reaming operation, drill rods are inserted at the exit end to maintain the path as the rods are removed from the original bore entry end.

All safety procedures must be observed for all stages of the operation. Although the initial pilot bore may not have caused any damage to an existing utility, the hole expansion caused by the larger diameter backreaming operation may cause such an effect.

If the hole expansion results in an electrical power strike due to a close miss on the initial bore, the exit end, with protruding steel drill rods, is also subject to electrical hazard. Therefore, when using such procedures, it is important that grid mats, ground rod, and an electrical bonding system also be used at the bore hole exit. In addition, for pipes constructed of metallic or electrical conducting materials, similar electrical safety procedures must be followed at the bore exit where the pipe assembly is fed into the hole during the pullback operation. It is assumed that all personnel will be wearing

electrical insulating boots and gloves at all times.

**! CAUTION !** *Electrical Utility: If possible, the electric power utility should be requested to shut off service in the area during the construction period. If not possible, arrangements should be made such that the automatic reclosure of circuit breakers is inoperative to prevent personnel exposure after the initial open circuit condition and loss of electric power.*

## 24.5 Environmental Considerations

The most common drilling fluid additive consists of bentonite, a naturally occurring clay. When added to water, the resulting fluid provides desired properties including viscosity, low density, and lubricity. The bentonite material used should be certified as per the National Sanitation Foundation. The bentonite-water slurry is not a hazardous material unless it becomes mixed with toxic pollutants when drilling through a contaminated area. Disposal should be in accordance with local laws and regulations. The waste material is usually considered as typical excavation spoils and can be disposed of by standard means used for other spoils. If other additives are of concern, or hazardous material disposal is required, it may be necessary to de-water the spoils, transport the solids to an appropriate disposal site, and treat the water to meet disposal requirements.

The utility access pits that may be present at both ends of the bore are convenient receptacles for collecting used drilling fluid. If not present for utility access, small pits should be provided at both ends to serve this function. The pits should be emptied as necessary. Some mini-HDD systems use drilling fluid recirculating systems to reduce the volume of spoils. If there is fluid penetration to the surface at an intermediate point along the bore path, the material should be promptly removed and the area cleaned. At some points along the route, in the vicinity of sensitive areas, it may be desirable to deliberately create a small vertical hole from the surface to the bore hole to provide a vent and locally relieve the fluid pressure. For example, this may be useful as the bore approaches a paved area, such as a driveway, in order to provide “controlled leakage” if it is suspected that leakage or break-through may otherwise occur at the paved area itself. Any vented fluid should be cleaned immediately after completion of the installation of the pipe.

The area at both ends of the bore should be maintained as clean as possible. Excess drilling fluid and mud may complicate the installation of the innerduct, and may get onto the grid mats, partially defeating the grounding characteristics of the equipotential grid mat system.

In some cases, it may be necessary to add grouting to the drilling fluid to ensure proper sealing of the bore hole to eliminate a possible passage for contaminants. Special drilling fluid pumps may then be required.

## 24.6 Regulations and Damage Prevention

All procedures should be consistent with the recommendations of the Common Ground Alliance, as documented in the *Common Ground, Study of One-Call Systems and Damage Prevention Best Practices*, August 1999, as well as the damage prevention procedures outlined in ANSI/EIA/TIA-590, *Standard for Physical Location and Protection of Below-Ground Optical Fiber Cable Plant*.

In general, the communications company should obtain any required drilling permits and approvals from the municipalities or other agencies that may be affected by the work. These approvals include easement, right-of-way, road crossing permits, franchise agreements, and physical design approvals. In order to avoid damage to existing facilities, all substructures must be identified, located, and avoided, including utilities such as electrical supply cables, natural gas lines, water and sewerage lines, pipes carrying other liquids, storage tanks, and existing communications cables.

All States have damage prevention laws that address the responsibilities of the other (non-communications) facility owners (i.e., owners of the other existing subsurface utilities) and contractors to avoid damage to existing subsurface facilities. The details of these laws may vary with respect to the types of utilities (e.g., sewer lines are often not serviced by all One-Call bureaus). It is important that the facility owners and contractors follow the letter and intent of the law. This implies that each facility owner should belong to a local “One-Call” notification service, and the contractor must “call before digging.”

**Note:** It is primarily the responsibility of the contractor to contact the One-Call center prior to construction activity.

**Note:** Some local regulations require the notification center(s) to be contacted at least 48 hours, but not more than 120 hours, in advance of actual construction, excluding weekends and holidays.

A National One Call “811” number is operable to facilitate contact with State One-Call notification systems (also see [www.call811.com](http://www.call811.com)). All USA states have a One-Call center; however, if local areas have no statute requiring central registries, the contractor must then search other government records and references to identify subsurface facilities. For example, utility-operating franchise areas may be obtained from the state public service commission, state corporation commission, Attorney General’s office, or directly from the utility company. Local political subdivision tax records and public works department plant records may be used to obtain information for other classes of facility owners, e.g., private corporations and government networks.

### 24.6.1 Locating and Marking

The mini-HDD contractor should mark the path of the proposed bore route in a color that will not be confused with that of the other facilities to be marked; white is recommended. It is the responsibility of each individual facility owner to mark the location of its utility lines, generally within 2 working days. Any facilities within 10 feet laterally of the proposed bore path should be marked, unless otherwise specified by state or other regulations. The existing subsurface facilities should be marked directly above by color-coded paint, flags, stakes, or similar means using the American Public Works Association (APWA), Utility Location and Coordination Council's (ULCC) *Uniform Color Code*, as provided in TIA-590 (see [Table 24-1](#)). The owner, type of facility, and width (if greater than 2 inches) should be indicated. If there are no facilities of a particular type within 10 feet, the corresponding owner should so indicate. In general, the depths of the utilities are not provided and must be determined by the owner of the proposed pipe line or the mini-HDD contractor.

**Table 24-1 APWA Uniform Color Code**

| <b>Color</b>            | <b>Facilities</b>                                           |
|-------------------------|-------------------------------------------------------------|
| <b>Red</b>              | <b>Electric power lines and conduit</b>                     |
| <b>Yellow</b>           | <b>Gas, oil, steam, petroleum lines</b>                     |
| <b>Blue</b>             | <b>Water, irrigation, slurry lines</b>                      |
| <b>Green</b>            | <b>Sewer lines, drain lines</b>                             |
| <b>Orange</b>           | <b>Communications lines, including optical fiber cables</b> |
| <b>White</b>            | <b>Proposed construction path</b>                           |
| <b>Fluorescent Pink</b> | <b>Temporary survey markings</b>                            |
| <b>Purple</b>           | <b>Reclaimed water, irrigation, and slurry lines</b>        |



**Figure 24-3 Facility Marking Examples**

If a particular utility operator does not visibly mark the locations of its lines, information should be provided to enable the contractor to determine the approximate location of the utility. The information should include a contact person and telephone number. Some facilities are non-metallic or may otherwise be difficult to locate. If necessary, and particularly for lines transporting electricity or gas, oil or petroleum products, or other flammable, toxic or corrosive fluids or gases, test pits (pot holes) should be dug to verify the actual location and depth of existing utilities.

**! CAUTION !** *It is highly desirable that utility lines be routinely exposed at all anticipated crossings with the bore path, such as where the bore path along a ROW crosses laterals or service lines to residences or structures. Electrically insulated (non-conducting) hand tools or special non-destructive "air pressure/vacuum" excavation systems are required for such purposes.*

For locally exposing utilities along the ROW, such operations should be initiated at a minimum distance of 18 inches on either side of the outer edge of the facility, unless otherwise specified by local damage prevention regulations, followed by carefully proceeding towards the utility. Construction may begin after all relevant subsurface facilities have been marked and verified. If it is believed or suspected that an existing substructure may have been damaged during any stage of construction, the contractor must immediately report the incident to the owner of the affected facility.

The general principles, techniques, and program represented by Subsurface Utility Engineering (SUE) may be adapted to organize the location and verification of the existing utilities in an organized and comprehensive manner. This includes an investigation of existing records, visual inspection of surface evidence, surface geophysical techniques, and actual digging using non-destructive methods, or some combination of these methods. The overall investigation and details are clearly recorded for convenient reference and usage.

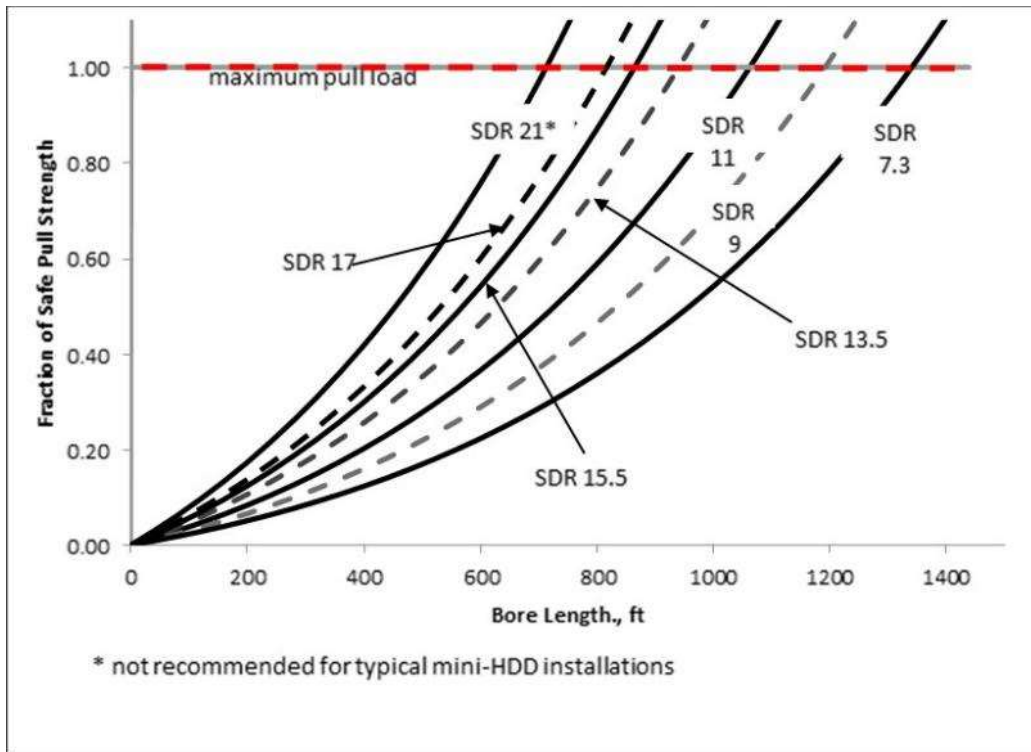
## 24.7 Product Pipe (Innerduct) - Placement Distances

The appropriate type of innerduct is described in [Chapter 23](#) of this manual and should meet the requirements of Ericsson - NIS document GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit, and Accessories*. For typical communications applications, High-Density Polyethylene (HDPE) innerduct of SDR-11 is recommended based on structural and handling characteristics, unless otherwise specified. Mini-HDD applications typically comprise short, shallow installations and, therefore, detailed calculations of pipe stresses and loads due to the installation forces are generally not necessary.

However, if pulling distances are on the order of 1,000 feet or greater and have several large bends, a more robust (thicker, lower SDR number) innerduct may be required.

[Figure 24-3](#) provides the maximum recommended placement distances for HDPE innerducts of various wall thicknesses based on the pulling strength, for “straight” installations, for typical size drill rods. For other cases, see Chapter 7 of the PPI (Plastics Pipe Institute) TR-46, *Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe*.



**Figure 24-4 Predicted Mini-HDD Pull Load vs. Safe Pull Tension**

[Courtesy of Outside Plant Consulting Services, Inc.]

[Based on an HDPE (PE-3608) Pipe with a Nominally Straight Path and a 2-inch Drill Rods Unit]

Innerduct is typically supplied as a continuous length on a reel, for sizes up to 4 inches or less. In general, intra-span couplings should be minimized or avoided. Such connections represent potential vulnerabilities with respect to leakage or pulling strength, and couplings may increase drag forces, or possibly snag, during pullback. When necessary, field connections may be made using mechanical couplings or, ideally, for HDPE duct or pipe, a fusion technique. Fusion splices essentially maintain the inherent integrity of the pipe with respect to pressure rating, leakage, and axial load capability. Mechanical couplings should comply with GR-356 and retain as much of the inherent pull strength of the innerduct as possible to allow successful placement during the pullback operation.

## 24.8 Bore Path Layout and Design

The communications company will provide the general requirements for the path of the communications line and innerduct, including location within the right-of-way, path of laterals to residence or building, etc. The actual layout, however, will vary from case to case, depending upon the specific obstacles or specified utility line architecture. For mini-HDD projects, the detailed bore path for each segment will be determined on-site, in advance of the operations, by the selected contractor and/or communications engineer.

The nominal depths will also be specified by the communications company, including minimum and maximum, and be consistent with other existing utility locations, as determined by the preliminary investigations. A minimum depth of cover of 36 inches is desired to reduce the potential for drilling fluid penetration to the surface and avoid the tendency for the drill head to rise to the free surface, thereby complicating the steering operation during the initial bore. Excessive depths may not be practical for future maintenance activities. Typical industry guidelines recommend a minimum ratio of 10-to-1 for depth of cover to final hole diameter to avoid surface heaving effects, for a compaction process in appropriate (i.e., compact-able) soil conditions. In such cases, spoils disposal is minimized since the displaced soil is compacted into the surrounding walls of the hole.

For less shallow burial, or non-compactible soil conditions, the drilling operation must use appropriate drilling fluids designed to remove at least a portion of the spoils during the initial boring or reaming operations. A greater volume of drilling fluid would generally be required to remove the soil from the bore hole in a soil removal process, in comparison to a compaction process. It is the responsibility of the contractor to understand and utilize drilling fluid technology to form the bore hole without surface heaving.

The contractor must understand the steering capability and limitations of his mini- HDD equipment. The planned path must be consistent with the steering capability of the drill string and the allowable radius of curvature of the steel drill rods based upon the corresponding bending stresses in the steel rods and joints. Although some soil conditions will inhibit sharp steering maneuvers, path limitations will often be based upon fatigue strength considerations of the rods. A rod may be able to withstand a single bend cycle corresponding to a relatively sharp radius of curvature, but the rotation of the rod during the boring operation results in a flexural cycle, which may eventually cause cumulative fatigue failure.

The diameter of the drill rod is an important parameter affecting its stiffness, steering capability, and the allowable bend radii. A conservative industry guideline indicates that the minimum bend radius (in feet) should be approximately 100 times the diameter (in inches) of the steel rod.

*Minimum bend radius (feet) = ~100 times the diameter (inches) of the steel rod*

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Since typical mini-HDD drill rods have 1- to 3-inch diameters, the corresponding bend radii are on the order of 100 to 300 feet. These limits apply to bends both in the horizontal (plan) or vertical (profile) planes.

In general, the allowable bend radius will be provided by the pipe manufacturer. For pipes or conduits constructed from plastic or other very flexible material, the bend radius limitation of the drill rods as given in the formula above are typically sufficiently large to be compatible with that of the product pipe.

### 24.8.1 Bore Path Profile/Trajectory (Vertical Plane)

The radius of curvature of the drill rod path and the entry angle of the rod to ground surface will determine the depths achievable at the beginning of the bore path.

Figure 24-4 illustrates a representative mini-HDD bore profile/trajectory, including pits at the entry area and possibly along the route. These pits may be required for splicing, completing lateral connections, or to expose existing utilities at critical points. The pits may also be useful for collecting drilling fluid from the boring or backreaming operations. In order to achieve a specified depth at a particular point (e.g., point 1 or 2, Figure 24-4) at the beginning of a bore, the front of the drill rig must be located an appropriate distance rearward (setback distance) from the point of interest. This distance will also depend upon the rod entry angle which is determined by the drill rack angle. Typical drill racks allow an entry angle in the range of 5 to 25 degrees, which is equivalent to a 10 to 45% grade.

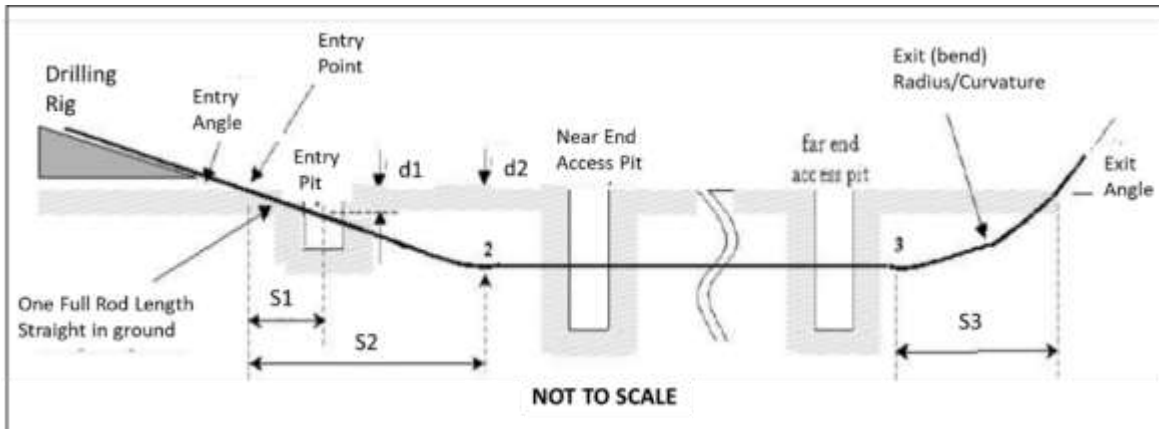
**Note:** Some locating systems provide the elevation angle in percent grade (vertical rise or drop per unit of horizontal distance times 100). The angle in degrees is approximately equal to half the percent grade.

The shortest setback distance (S1, Figure 24-4) corresponds to a bore path segment comprising a straight line extending from the drill rig directly towards the point of interest (point 1, Figure 24-4). It should be noted that the depth of the bore path will continue to increase beyond this point, over the distance required for the drill rods to develop a concave-up curvature and achieve a horizontal trajectory.

If it is specified that the bore path be essentially level at the depth and point of interest, a longer setback distance (S2) will be required to allow the path to reach the desired depth, and a horizontal trajectory, at a decreasing rate of descent. This corresponds to the geometry leading to point 2. In this case, it is assumed that the bore is initiated along a straight path, without any curvature or steering, for a distance equal to one full drill rod length (e.g., 10 feet for many machines) in the ground. This recommended practice helps avoid lateral bearing loads at the front of the drill rig. The upward desired curvature may be introduced during the placement of subsequent drill rods.

The minimum setback distance corresponds to a path with the first few rods inserted such as to continue the straight (sloping) trajectory, to descend as rapidly as possible, and the subsequent rods placed with the leading rod then creating a path at the minimum allowable bend radius.

**Figure 24-5 Mini-HDD, Bore Path Profile/Trajectory (Vertical Plane)**



Owing to the recommendation that the first rod be placed in the ground such as to define a straight entry, and its subsequent path curvature be consistent with the minimum allowable radius of curvature, there is a minimum depth at which the trajectory will become level, depending upon the entry angle. In some cases, the trajectory may exceed the desired depth, i.e., beyond the point of interest, such as the entry pit. If it is necessary to remain within a specified maximum depth along the entire path, including in the vicinity of the entry point, a more shallow entry angle or sharper bend radius, or both, would be required.

If the determined setback distances or drill-rig rack angle consistent with the project maximum depth specifications are not practical, consideration should be given to receiving approval from the communications company allowing increased depths in the transition area following the entry pit. If necessary, smaller diameter, more flexible drill rods may be considered if consistent with anticipated thrust and torque loads. Smaller bend radii than the nominal recommended limits may be used by the contractor if it is recognized that reduced service life may result for the drill rods. If the steering conditions in the soil preclude a sufficiently sharp upward turn, mechanical assistance may be provided at the entry pit to apply an upward bending moment on the rod.

Figure 24-4 also illustrates the horizontal distance (S3) required for the head of the drill string to reach the surface from its present bore path. The minimum distance to reach the surface from a point on a level trajectory (point 3) corresponds to that of steering upward at the minimum radius of curvature.

### 24.8.2 Bore Path (Horizontal) Planar Trajectory

In plan view, typical bore paths are relatively straight trajectories between the entry and exit points, and pass through intermediate access points, as required. A degree of route curvature in the horizontal plane may be accommodated by the steering capability of the mini-HDD system, consistent with the recommended bend radius of the drill rods (and product pipe) and steering capability within the soil.

### 24.8.3 Overall Bore Path Layout

The contractor must understand the ROW constraints and the general path requirements and utility line architecture for planning the bore paths. This includes paths for distribution lines along the ROW and for services for individual residences or structures. The anticipated route must take into consideration the location of other existing utilities.

For a smooth level area without any underground utilities, a visual survey and simple sketch may be sufficient for defining the bore route. In more complicated situations, a transit or other type survey may be required. In general, a proposed bore path plan view and profile layout should be prepared indicating the surface grade and important surface features, location of existing below-ground utility lines, reference points, etc. The bore path layout should also show anticipated access pits for utility connections or lateral service lines, and the bore depth at critical points such as access pits or utility lines, as well as at other reference points along the route. For relatively regular surfaces, a taut string at a convenient height, spanning the distance between the entry and exit points, will establish the average grade of the bore, representing a basis for the nominal elevation of the bore path. More advanced laser-based technologies may also be used. The string may also provide a reference for verifying the proper depth during the actual operation in the presence of minor surface depressions or irregularities, and serves as a basis from which to interpret the guidelines of [Section 24.8.1, “Bore Path Profile/Trajectory \(Vertical Plane\),”](#) which assume a level surface grade. For large surface depressions or mounds (e.g., of height greater than the depth of interest and extending over a long expanse, on the order of the minimum drill rod bend radius or greater), the bore should attempt to follow a path at the nominal specified depth below the average surface profile.

The path should avoid unnecessary bends and consecutive left and right, or upward and downward curves. Such trajectories are difficult to follow and may lead to over-steering and excessive bends, resulting in increased stresses in the drill rods and greater required pulling forces during the installation of the innerduct or subsequent cable. A heavy rope or line placed on the surface may serve as a convenient means of defining a gradual curve consistent with the desired path radius of curvature.

A sample sketch of a proposed bore path layout should be prepared; local

reference points should be included. This sketch also provides the basis for an “as-built” drawing ([Section 24.9](#)) to record any deviations from the intended path. More advanced electronic-based technologies may also be used to define the bore path, as well as possible deviations for the as-built drawings.

The deviation of the actual bore route from the proposed path should be within a specified tolerance to meet the intent of required separations from existing facilities. Both vertical and horizontal limits should be specified by the communications company, consistent with local regulations.

**Note:** Some state regulations require that new construction activities be a minimum of 18 inches from either side of the outer edge of existing facilities, as marked.

Unintentional bore path deviations may result from attempting to follow a bend with sharp curvature, drill head misalignments caused by cobbles or other obstacles, or soil conditions in general. Deviations may be reduced by decreasing the interval between successive drill head location determinations. Unless otherwise specified, the drill head should exit at the surface or access pit within a 12-inch radius of the target point. It is generally less difficult to meet such a condition for a target point in a pit than at the surface in a gradually rising bore profile (see [Figure 24-4](#)). The allowable horizontal and vertical deviations along the bore route should also be specified by the communications company. Typically, horizontal and vertical deviations along the bore route should be within  $\pm 18$  inches of the proposed path.

To help maintain an 18-inch separation from an existing facility along the route, the proposed bore path, including the radius of the widest cutter/reamer, should be at least 36 inches laterally offset from, or below or above the verified depth of the closest edge of the facility. An exception includes the case of the bore path crossing an exposed utility, at which point the desired physical separation, or non-interference, can be positively verified.

## 24.9 Implementation

The following information describes and summarizes the sequence of events during the actual implementation of the mini-HDD operation, consistent with the guidelines provided above.

Mini-HDD is a complex operation, requiring extensive skill and training. Thus, the mini-HDD crew must be properly trained and knowledgeable about the technical operation, safety, and environmental issues. Operating manuals are available from equipment manufacturers, and generic manuals providing operational and safety procedures are also available in the industry. It is beyond the scope of this manual to provide detailed operational procedures for the various equipment. Contractors should be



required to demonstrate evidence of proper training for their crews, including classroom and field experience for the primary personnel. The following items represent some of the issues related to the implementation process for placement of pipe or conduit.

The drill-rig unit is positioned consistent with the desired duct depth and bore route. Proper anchoring is especially important for soft or sandy soils. Anchors are placed into the ground at the front of the equipment by an impact or screwing operation.

**! CAUTION !** *The anchors are driven several feet into the ground and may represent potential damage to below-ground facilities. It is necessary to ensure that there are no facilities immediately beneath the front of the rig, including private lines installed by the homeowner.*

Mini-HDD operations begin with the initial pilot bore. Different ground conditions will require different type drill heads for the pilot bore operation. Appropriate drill heads are recommended in the manufacturer equipment or training manuals. Proper care and handling of the drill rods is important to avoid breakage during boring or backreaming. The threads must be cared for and properly coated (i.e., “greased”) when inserted into the drill string. Proper torque should initially be applied to the drill rods as added at the bore entry end to avoid potential loosening of the rods and loss of connection in the ground. In general, deliberate steering should not be attempted until one rod length (e.g., 10 feet) has been inserted straight (while rotating) into the ground. Premature steering will tend to produce lateral bearing loads at the front of the rig and complicate the insertion of additional rods. Creating or following turns of smaller than recommended bend radii will increase stresses and accelerate potential fatigue failure of the drill rods, a cumulative phenomenon.

Drilling fluids serve a very important role in mini-HDD operations. The fluid provides lubrication during the pilot boring, reaming, and pullback operations, to reduce the required torque and thrust or pullback loads. The drilling fluid also stabilizes the bore hole, cools the drill head (and internal transmitter), and may be used to remove cuttings and spoils for relatively large bores. In addition, the drilling fluid pressure may provide cutting assistance during boring. If mud motors are required, substantially larger volumes of drilling fluid will be required, possibly requiring drilling fluid recirculation systems. The crew must be trained in the proper use of drilling fluids, and the appropriate types for various ground conditions.

**Note:** Excessive drilling fluid pressures or volume may result in appearances at undesired surface locations or greater disposal problems.

### 24.9.1 Tracking and Locating

Adequate communications must be established and maintained between the operator of the drill rig and the individual performing the tracking and locating function during the initial boring procedure. Although some systems provide remote delivery of the locating information directly to a display at the drill rig, communications are still required to coordinate operations. Lack of communications may result in hazardous situations. Radio communications should be used for distances exceeding 50 feet or when out of sight. If communications are disrupted, the drilling operation must be halted until communications are restored.

In order to maintain the actual bore along the planned path, location measurements should be made at least once every 10 feet, when adding drill rods. For paths with horizontal or vertical turns, or in sensitive areas including the vicinity of other utilities, shorter intervals (e.g., 5 feet) are recommended. In areas with cobbles or other obstacles that may divert the drill head, measurements should be made whenever contact with such obstacles is suspected. A misdirected drill head may soon impinge into the vicinity of an adjacent utility and must be corrected as soon as possible. Measurements of drill head roll angle, bearing, or elevation may vary immediately after an initial reading; this effect may be minimized by rotating the drill string in place (without thrust, but with fluid flow) for several rotations before taking readings. The bore path should be marked with a flag or other marker at each location point.

Tracing signals present for identifying existing utility lines should be removed prior to the boring operation to prevent possible interference with the pilot hole tracking and locating operation. Signals may have been placed on existing metallic facilities or on associated tracer wires.

**Note:** Some non-metallic optical-fiber cables utilize a separate tracer wire that carries a characteristic signal to facilitate the cable location procedure, which may be in the same frequency band used by some mini- HDD locators. The responsible facility owner should be contacted to remove such signals, if suspected to be present.

A record of the planned and actual “as-built” bore path, including planar and profile views and vertical and horizontal deviations, must be submitted to the communications company. The paths should be described relative to existing references, such as curbing or other permanent structures. Significant features should be indicated, such as proximity to adjacent utilities, and particularly crossings. Unforeseen obstacles encountered during the drilling process should also be indicated. Additional information may also be included, such as steering or correction commands, duration, final bore hole size (i.e., diameter of reamer or compactor), drilling fluid usage (during pilot bore, reaming and pullback), and the type of drill head and reamer(s) used. This information will be useful for subsequent operations in the project area. The path position relative to local reference



points should also be indicated.

### 24.9.2 Reaming

In some mini-HDD applications, a backreaming operation to increase the hole size is not required such as when placing a single innerduct of less than a 2-inch diameter. However, a backreaming operation is required to produce a hole size sufficiently large to readily install a bundle of ducts. Appropriate soil cutters and compactors are recommended in the manufacturer equipment or training manuals, including drilling fluid usage. In some cases, several reaming operations are required. In general, pre-reaming is not required for placing product pipe(s) of a 4-inch diameter or less, and the reaming and product pipe pullback may be performed simultaneously. The pre-reaming operations allow relatively large holes to be created in stages, reducing the required torque and thrust loads at the machine. Pre-reaming also reduces the possibility of voids or surface heaving or settlement, including unanticipated drilling fluid appearances. Hole diameter (i.e., compacted) increments should be restricted to approximately 6 inches or less during a single pass. A final hole diameter at least 50% greater than the outer diameter of the duct (or innerduct bundle) is recommended to provide clearance for innerduct grips, allow spoils flow, and reduce the required loads during the duct pullback operation.

During pre-reaming, additional drill rods must be available at the pilot bore exit which are connected to a swivel at the rear of the reamer and pulled into the hole to maintain the path. It is important to closely adhere to the electrical safety aspects regarding pre-reaming operations to avoid electrical shock at the bore exit end where the rods are added.

### 24.9.3 Gripping and Pulling

There are several common methods for gripping the product pipe (innerduct) during the pullback procedure. This includes an external basket-type grip, an internal threaded grip, and an internal/external clamping or bolting device. If a basket-type grip is used, the pulled end of the duct must be plugged to prevent entry of dirt, debris, or drilling fluid. A rigid insert will also prevent the end of the duct from collapsing under the grip. The open end of the basket grip should be taped tight to prevent loosening. If a bundle is being installed, a separate grip should be used for each innerduct. The position of the grips should be staggered to avoid a single large bulge.

A swivel is required between the reamer or compactor preceding the duct(s) to prevent the transmission of torsional loads to the product pipe(s). In general, the rating of the swivel should be at least as large as the total strengths of the bundle of ducts to be installed, but not excessively greater. Inefficiencies in overly large swivels may result in relatively significant twist transmitted to small ducts. The maximum strengths of the individual ducts, including couplings, may be provided by the manufacturer.

The pulling loads required at the drill rig and reflected in the hydraulic pressure gauges at the control panel, will typically exceed the tensions experienced by the duct. Much of the applied pullback force is necessary to ream or compact the hole, or pull the drill rods through the path, and is not applied to the duct itself. However, for critical applications, it is recommended that individual breakaway links be provided between the main swivel and the grip(s) at the duct(s), to ensure that the ducts are installed within allowable load levels. Each breakaway link rating should be within the total safe working load of its corresponding duct (including couplings). Although less desirable, a single breakaway link may be used for a bundle of ducts. The corresponding safe working loads for the individual ducts in the bundle are added to determine the total safe working load and the corresponding rating of the breakaway link. A broken link will require removal of the duct(s) from the entry end, or possible abandonment of the duct. A new path may have to be drilled after determination of the reason for the initial failure. The use of breakaway links is not necessary for typical communications applications involving the placement of vacant innerduct (i.e., not containing pre-installed cable).

If a breakaway swivel is used as the breakaway link and is not specifically designed for direct exposure with soil, this item should be cleaned well after each application. The use of a breakaway swivel does not necessarily eliminate the need for the main swivel described above.

Extension interruptions in installation may lead to increased frictional drag and pulling forces, including that due to loss of integrity or collapse of the bored and reamed hole, significantly inhibiting or preventing the insertion of the product pipe. The use of innerduct commonly supplied in long, continuous lengths, on a reel, helps avoid unnecessary delays in completing the installation.

The duct should not be supported on an area that may cause snagging, abrasion or other damage as it is pulled into the hole. Back tension must be avoided to prevent the escalating effect this may have on the resultant pulling forces required at the leading end. Special care must be exercised when handling the innerduct to ensure that it is not subject to excessively sharp bends that may kink or otherwise result in damage. The manufacturer's recommendations should be followed regarding the minimum bend radius when feeding the duct directly into or out of the various pits along the route or redirecting the innerduct path at an intersecting bore. Particular care should be exercised if the innerduct is pulled under significant tension since the resulting side wall bearing pressure at a sharp bend can cause local crushing. Thus, the procedure of pulling additional duct length directly from the surface and out of the bore entry (duct exit) pit requires caution. Sharp bearing corners should be cut and relieved corresponding to bends consistent with the minimum recommended radius or greater.

## 24.10 Inspection and Site Cleanup

The pits should not be filled until approval is received from the owner or his/her representative. Some pits may be used for the placement of terminals or other connections by the owner and should not be filled until the operations are completed. The integrity of the innerduct path should be verified by pulling a mandrel through the installed duct or by brief pressurization, as described in [Section 23.4.2, “General Considerations.”](#) For an ongoing project involving the placement of a large amount of innerduct, such inspections may be performed on a sampling basis to maintain quality control of the overall process, as specified by the communications company.

The as-built drawings shall be submitted to the communications company to indicate that the duct path was placed at the proper location and depth, or within acceptable limits. The communications company may elect to independently verify the location or depth by:

- a. Careful digging (e.g., using hand tools to minimize possible mechanical impact damage to duct) at discrete points along the path to gently expose the duct, or
- b. Using an internal transmitter placed within the innerduct in combination with a surface locator to more precisely locate the duct.

After approval, the pits must be filled, the soil compacted, and the surface area restored to its original condition. The site must be cleaned of equipment, tools, and spoils, consistent with [Section 24.5, “Environmental Considerations.”](#) All drilling fluid must be cleaned from the site or its vicinity.

## 24.11 Informative References Related to Directional Drilling

For more detailed functional performance requirements for innerduct and conduit, consult the following references:

1. IEEE 1333, *IEEE Guide for Installation of Cable Using the Guided Boring Method*. (Though officially superseded, this 1994 guidance document is available from IEEE.)
2. *Horizontal Directional Drilling Guide*, North American Society for Trenchless Technology (2015) - A Comprehensive Look at the North American HDD Industry ([www.trenchlesstechnology.com](http://www.trenchlesstechnology.com)).
3. TR-46, *Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe*. (Plastics Pipe Institute - [http:// plasticpipe.org](http://plasticpipe.org)), 2009.
4. OSHA 3075, *Controlling Electrical Hazards*.
5. *Common Ground, Study of One-Call Systems and Damage Prevention Best Practices*, 1999 - Sponsored by the US Department of Transportation: Office of Pipeline Safety.
6. TIA-590-Revision A, *Standard for Physical Location and Protection of Below- Ground Optical Fiber Cable Plant* (1997).

## 25 Bonding and Grounding - Drop Cables and Service Wires

### 25.1 General

Proper bonding and grounding is a requirement for every service installation. The type of ground required and the method of implementation will vary, however, based upon the installation environment.

This chapter covers the general requirements for bonding and grounding communications drop wire and cable at building entrances. Installation shall be in accordance with the NEC, the NESC, and any applicable local building/electrical codes. The NEC and NESC are largely in harmony with the NEC code being the primary code of reference for grounding and bonding requirements pertinent to the communications service drops and connections at the point of entrance or demarcation points on the customer premises.

The reader should also refer to Chapters 10 and 14 of this *Blue Book* for discussions on bonding and grounding in aerial equipment (i.e., pole-mounted equipment) and to Chapters 17 and 20 for further bonding and grounding procedures in buried and underground plant facilities.

#### 25.1.1 Changes in 2017/2023 Editions of NESC and NEC

##### Intersystem Bonding Termination (IBT)

NEC Rule 250.94 in the general grounding Article 250 was improved and clarified with explicit reference to communications added to the title, the consolidation of IBT requirements into new 250.94(A), and the addition of an optional copper busbar permitted as an IBT in a new 250.94(B).

The parallel sections in Chapter 8 (Communications) and Article 770 (Optical Fiber Cable) covering bonding and grounding were harmonized and clarified between Section 770.100 and the consolidated common requirements in 800.100 inclusive of the various communications cable types covered in Articles 805, 820 and 830.100] (see Section 25.3 for further discussion).

Within the NESC (Rule 099C), the bonding conductors to these IBT units or to the grounding electrode are specified as a 6 AWG (minimum) bond wire, which is larger than the 14 AWG permitted in some circumstances by the NEC. The 6 AWG is already standardized across most communications companies for this bond to the Intersystem Bonding Termination (IBT). The size of the bonding and grounding conductors internal to communications equipment and inside closures/boxes can vary between 14 AWG and 6 AWG depending on voltage/current demands of the circuit and application. For tower grounding, larger conductors (2 AWG) are necessary to match the lightning and possible power cross events.

NESC Rule 097G covers intersystem bonding between communications and power systems in the aerial plant of the distribution network. In the 2017 NESC, Rule 097G was reformatted for clarity and new guidance was added to Rule 384C as a note covering the connections to the vertical pole ground.

**097G. Bonding of communications systems to electric supply systems**

*Where both electric supply systems and communications systems are grounded on a joint use structure, and a single grounding conductor is present, the grounding conductor shall be used for connected to both systems. Where separate supply and communications grounding conductors are used, they shall be bonded together.*

*EXCEPTION 1: Where separation is required by Rule 097A.*

*EXCEPTION 2: Where the electric supply utility is maintaining isolation between primary and secondary neutrals, the communications system ground shall be connected only to the primary grounding conductor. if it complies with the requirements of Rule 097C.*

**384-C.** Bonding should be provided between all aboveground metallic supply and communications enclosures that are separated by a distance of 1.8 m (6 ft) or less. For the purpose of this rule, pole grounds are not required to be bonded to the communications enclosure

“Note: This rule does not prohibit bonding communications metallic enclosures to supply pole grounds, providing all parties agree”

The note added to 384C requires an explicit agreement because of the understanding that there are circumstances where bonding between the vertical pole ground from power circuits and an adjacent communications pedestal may create a more hazardous situation than not bonding. One does not wish to connect the grounding systems together if the result will be the more readily introduction of foreign voltages from the power circuits or power faults into communications shields and circuits.

### 25.1.2 Grounding Rods and Locations

Clarifications to NESC Rule 094 on acceptable ground rods revealed concerns with commercial criteria (“trade sizes”) and preferred material choices that shall need further work and research in the next NESC code cycle and in revisions to product specifications (see 25.3.3 and 25.3.3.1 for further detailed discussions).

NESC Rule 096 was modified in 2017 and 2023 to allow exceptions for 4 grounds in every mile for cases of long uninterrupted spans, such as across valleys and under waterways, where long runs (spans) of cable occurring

without any splice makes access very limited or impossible. Correlating changes were made in Rules 342 and 354D to require that an effective ground be established at the first opportunity on either side of the long span.

### 25.1.3 New Expanded Article 840

NEC Article 840 was introduced in the 2011 code cycle to cover optical fiber (FTTH) systems. In 2017, the article was broadened to cover other network architectures that are customer-powered. Article 840 covers customer-powered systems that use twisted copper pairs or coaxial transmission media for Power-over-Ethernet (PoE) and reverse-powering (e.g., G.Fast) networks with a prescribed limit of 60 watts per circuit.

The new article has many explicit cross-references to other parallel NEC articles of 770, 800, 805, 820 and 830 (see Section 25.4 for scope descriptions of the different applicable Chapter 8 articles of NEC Chapter 8). For systems with more than 60 watts per circuit, the NEC points to Article 725.144 where the conductors and cables are treated similar to low-power circuits.

**Note:** The changes in Section 840.160 covering the powering limitations for the conductors providing PoE services remain under vigorous discussion and are expected to be revised further in the next code cycle through task groups and industry discussions covering articles in both Chapter 7 and 8 of the NEC. The primary safety issue within 840.160 and parts of Chapter 7 was the concern of possible over-heating of conductors inside bundled cables where many of these powering circuits are compressed together.

A large consolidation effort was accomplished over the last 2 code cycles for 2017 and 2023 editions of the NEC to bring common requirements for communications circuits/cables under the general Article 800 with specific exceptions and detailed conditions for the different cable types residing in their individual applicable Articles of 770, 805, 810, 820, and 840 (see Section 25.4).

### 25.1.4 Historical Perspective - Changes in the 2011 NEC (from Issue 5)

**Note:** This section was reproduced from Issue 5 of the *Blue Book* and has been retained here for historical reference and background information on the NEC code.

The new Article 840, “Premises-Powered Broadband Communications Systems,” was added in the 2011 edition to cover premises-powered, optical fiber-based broadband communications systems that provide a combination of voice, video, data, and interactive services through an Optical Network Terminal (ONT) located on or inside the customer premises. The ONT is back fed with power from the customer. A typical system configuration consists of an optical fiber cable to the premises (FTTP) supplying a

broadband signal to an ONT that converts the broadband optical signal into component electrical signals such as traditional telephone, video, high-speed Internet and interactive services.

Powering of the ONT is typically accomplished through an ONT Power Supply Unit (OPSU) and Battery Backup Unit (BBU) that derives their power input from the available AC at the premises. The optical fiber cable is usually all dielectric (i.e., non-conductive), although some armored cables may have metallic shields or metallic support strands that are conductive.

There was some confusion in the field regarding the grounding of premises-powered broadband communications systems provided over a non-conductive optical fiber cable, and why grounding requirements for these systems should differ from those of the more conventional “metallic” telephone and CATV systems. A separate Article 840, rather than inserting requirements within a number of existing articles, will enhance NEC usability by placing all requirements for premises-powered broadband communications systems in a single location. This arrangement will serve both to highlight and to inform installers as to the similarity to, and differences from, the grounding requirements in Articles 800 (traditional telephony systems), 820 (traditional CATV systems) and 830 (network-powered communications systems).

The ONT in these systems provides a single point at which the power supply, CATV, telephony and data (Internet) services are co-located, and it is imperative that the grounding at this point is not inadvertently disconnected. For example, unplugging the ONT for maintenance, replacement or repair should not disconnect the grounding connection provided for safety.

### 25.1.5 Grounding and Bonding Terminology

In the NEC, the general term “grounding conductor” has been replaced with the more precise terms of “grounding electrode conductor” or “equipment grounding conductor” or “bonding conductor” or “bonding jumper” as appropriate.

***Grounding Electrode Conductor (GEC):*** A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

Figure 25-1 illustrates the use of new terminology for the typical intersystem bonding terminations and grounding conductors used in communications service drop configurations. Users need to be aware of this change since the term “grounding electrode conductor” has historically identified the specific conductor that connects the grounded supply conductor (neutral) and equipment grounding conductor from within the power service equipment to the grounding electrode/ grounding electrode system at the premises. In the old communications terminology, the “grounding conductor” included characteristics of both the grounding



electrode conductor and the bonding conductor.

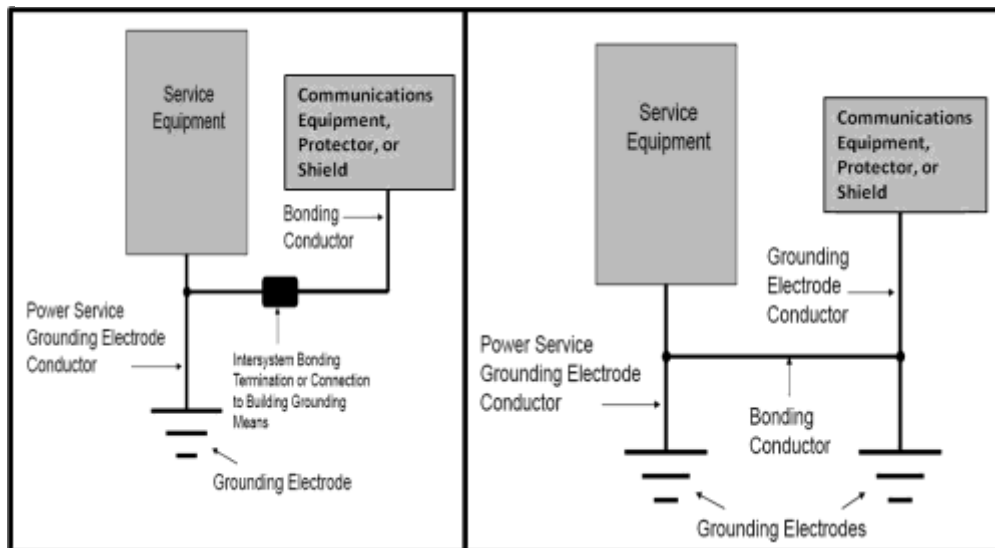
Along with these NEC changes in definitions and usage, one should also note the definitions of the related bonding terms such as the following:

***Bonded (Bonding):*** Connected to establish electrical continuity and conductivity.

***Bonding Conductor or Jumper:*** A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

For these purposes, the term “grounding” means a connection to earth, while bonding is a conductive connection between two metallic objects and does not necessarily imply a connection to earth.

**Figure 25-1 Examples of Terminology for Grounding and Bonding Connections**



In general, we shall use the new “grounding electrode conductor” terminology in the *Blue Book* unless the use of the traditional term “grounding conductor” improves the textual clarity and better matches the safety intent and objective of the offered guidance. The traditional term “grounding conductor” as used in the communications industry covered both grounding and bonding conductors by the NEC definitions.

Quite often the communications grounding conductor is more correctly a bonding conductor, but the use of “grounding conductor” remains widely used in the communications industry with the focus being on its ultimate function, i.e., a conductor that helps provide an effective, low-resistance pathway to ground or earth.

## 25.2 Purpose of Grounding (and Bonding)

Grounding a communications cable sheath or a coaxial cable shield limits voltages that may be present from external sources such as power contact, power faults, or lightning. Grounding promotes rapid de-energization of power lines that contact the communications plant.

Appropriate Bonding and Grounding (B&G) practices help reduce electrical risks and hazards to employees who may accidentally contact energized lines, as well as to equipment exposed to collateral effects from power faults and lightning strikes. The best B&G practices cannot prevent the damage that may result from power crosses events and the effects of lightning strikes. However, following these B&G practices does provide a means to greatly limit the damage and hazard to persons and facilities.

Good B&G practices can also reduce galvanic and electrolytic corrosion to cable shields, pole guys, anchors, equipment enclosures, and associated hardware by draining away undesirable voltages and currents. The elimination of such foreign and induced voltages/currents can also reduce noise in communications circuits and thereby improve service quality.

Cables entering a subscriber's building must be bonded together to reduce the overall resistance to ground and to minimize the potentials that might appear between them. The continuity of the path to ground (earth) must be maintained at all times. Common bonding between the telephone protector ground and the power service grounding system is required by the NEC at the customer premises. This common bonding practice will help protect possible injury or damage caused by differences in ground potential between the two systems (power and communications).

### 25.2.1 General Work Rules and Precautions

Following the correct operational methods and procedures, as well as instituting appropriate engineering controls, are the primary defenses against the electrical risk and hazards in the workplace. Examples of such steps include:

- Voltage testing before contact with poles, brackets, equipment closures, and associated hardware.
- Lock-out/Tag-out procedures when possible.
- Assume all supply lines are energized to their full operational voltage levels.
- Maintain more than Minimum Approach Distances (MADs) specified in NESC Rule 432 from all supply lines and equipment.

At the customer premises and building entrances, the technicians should follow all applicable safety practices and

- Properly ground every Network Interface Device (NID) in accordance

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with the instructions of the NID manufacturer and the guidelines found in GR-49-CORE, *Generic Requirements for Outdoor Telecommunication Network Interface Devices (NIDs)*.

- Ensure that the grounding Order of Preference is followed and the best grounding choice is selected based upon that particular installation.
- Place a ground tag in close proximity to the primary grounding point (i.e., Primary Grounding Electrode or PGE). The tag must be firmly secure (e.g., zip-tied) to the #10 or #6 AWG ground wire connected to the NID.
- Verify that continuity exists with the grounding path on every installation and/or maintenance order where a NID has been either placed or replaced.
- Torque all connections properly. If no torque level is specified by the manufacturer or equipment supplier, then the following torque values should be used:
  - Typical general torque force necessary to install and disassemble parts shall be between 15 and 25 ft-lb torque.
  - For individual bonding and grounding devices using threaded hardware, the maximum torque to attain an effective electrical connection will usually be:
    - Less than 150 in-lb (12.5 ft-lb) for screw/bolt threads greater than 1/4-inch diameter
    - Less than 50 in-lb (4.2 ft-lb) for screw/bolt threads smaller than 1/4-inch diameter
    - Less than 50 in-lb (4.2 ft-lb) if hardware is designed to be tightened with a screwdriver only.

General safe work practices apply to every aspect of a technician's job functions, including when grounding a NID. In the context of this grounding and bonding chapter in particular, the following practices apply in situations when a technician is installing service or making repairs:

- All points at which a technician is either intending to touch, or may accidentally come into contact with, outside the premises or inside the premises must be tested with a hazardous voltage test set prior to beginning the work. These points include the ground point, power meter box, AC units, AC disconnects, and cable ground that are in close proximity to the work area.
- Prior to working in plant, technicians must test all pedestals and sheath grounds with a hazardous voltage test set.
- Never remove another utility's (i.e., power or cable company) ground clamp from its selected Primary Grounding Electrode (PGE) point.
- When visiting customer premises and subscriber buildings, the technician should inspect the ground wire, grounding clamps and any associated connectors looking for any

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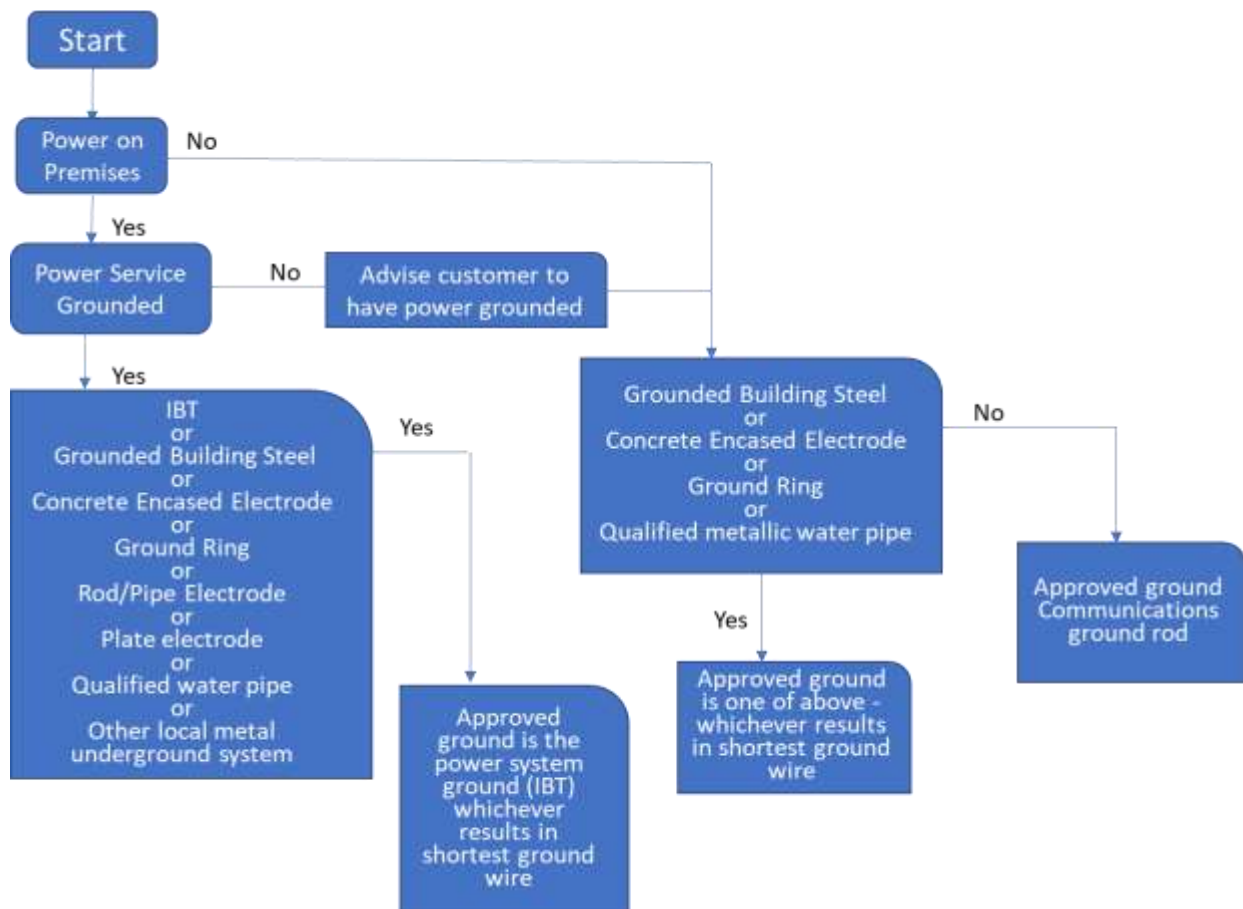
- Broken or disconnected wires
- Loose connections
- Defective, damaged, or corroded hardware
- Grounding and bonding conductors that have kinks or sharp bends.

Any of the above conditions found shall be repaired or components replaced to help ensure an effective bond and ground connection.

- If the grounding conductor is not connected to the best available ground electrode in accordance with the discussion in [Section 25.3](#) and [Figure 25-2](#), change the ground to conform to [Figure 25-2](#), or bond separate grounds together using a No. 6 ground wire. Ensure that the ground, power-service ground, and interior metallic water pipes are bonded together.

**Figure 25-2 Selection (Flow Chart) of Approved Ground**

(Use in Conjunction with Section 25.3)



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**Note:** A qualified or acceptable metal underground water pipe is one in direct contact with the earth for 10 feet or more (including any metal well casing effectively bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or sections or insulating pipe) to points of connection of the grounding electrode conductor and the bonding conductors. Interior metal water piping located more than 5 feet from the point of entrance to the building shall not be used as a part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system.

## 25.3 Bonding and Grounding at Customer Premises

**! CAUTION !** All grounds and bonds must be as **short and as straight as practical** and be made as close to the point of the wire entry into the building as possible. Avoid sharp bends in grounding and bonding conductors.

The increasing use of nonmetallic underground piping (e.g., concrete or plastic) has made both public and private water systems substantially less reliable as grounds than when water systems were constructed of metal piping exclusively. New construction very often uses plastic underground piping, and existing metal systems are often repaired, replaced, or altered using plastic piping.

### 25.3.1 NEC Perspective of Grounding at Service Demarcations

The applicable and relevant sections of the NEC include the following:

- Article 800 describing the general grounding and bonding requirements for communications cables of all types that apply across all the other articles within Chapter 8 of the NEC.
- Article 805 describing the specific bonding grounding of traditional telephony type communications cables that use twisted pair insulated copper conductors.
  - A licensee's drop wire or cable cannot be attached to, or be supported by, the existing communications (telephone) company's hardware facilities. Drop wire cables shall not obstruct climbing space. See Section 3.9, "Climbing Space," and the NESC rules referenced therein.
- Article 810 covers coaxial cabling and other lead-in wire from satellite type (dish) and radio antennas with specific B&G requirements to match that media.
- Article 820 describing grounding of coaxial cable shield (associated with traditional CATV type systems in HFC networks)

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- Coaxial cable used for CATV service drops are generally equivalent to twisted pair drop cables in terms of their breaking strength and shielding characteristics and shall be placed to conform to the National Electrical Safety Code (NESC) with respect to clearances, span lengths, and minimum stringing sags for light, medium, and heavy loading areas.
- Article 830 describing Network-Powered Broadband Communications Systems as found in certain FITL and xDSL architectures
- Article 840 describing Premises-Powered Broadband Communications Systems found in FTTH networks as well as services based on metallic (twisted pair and/ or coaxial) media. Article 840 B&G practices point to other articles for the appropriate media type (twisted pair, fiber, etc..) such as Articles 779, 805, or 820.

**Note:** For the 2017 Edition of the NEC, the scope of Article 840 was expanded from only Optical Fiber (FTTH) systems to include all customer-powered network architectures which includes, for example, (a) the use of twisted pair cables of Cat 5e, 6 and 7 with high transmission capacities for supplying Power-over-Ethernet and other broadband services, and (b) coaxial and twisted pair cabling from local customer owned/powered antenna equipment to gateway hubs inside the building with wireless connections to Customer Premises Equipment (CPE).

- Article 250 describes the general grounding of power services with the specific intersystem bonding terminations for communications covered in Article 250.94. This article was reformatted and revised for the 2017 Edition, adding an explicit reference to “communications” to the title, the consolidation of IBT technical requirements into new 250.94(A), and the addition of a new section for an optional copper busbar permitted as an IBT in a new 250.94(B). Within 250.94, a reference to the applicable sections and articles within Chapter 8 provides for equivalent alternate grounding and bonding for specific communications cabling types.

The repeated references to “supplied by a feeder or branch circuit” introduced into 250.94 were added to cover the cases where communications service is delivered to an out-building, barn, shed or other subsidiary structure which is also served by AC power. The full Article 250.94 from 2023 NEC is provided below for reference:

***250.94 Bonding for Communications Systems.*** Communications system bonding terminations shall be connected in accordance with (A) or (B).

*(A) The Intersystem Bonding Termination Device. An intersystem bonding termination (IBT) for connecting intersystem bonding conductors shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any additional buildings or structures that are supplied by*

*a feeder or branch circuit. If an intersystem bonding termination device is used it shall comply with the following:*

- (1) Be accessible for connection and inspection.*
- (2) Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors.*
- (3) Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment.*
- (4) Be Securely mounted as follows:*
  - a. At the service equipment, to a metal enclosure for service equipment, to a metal meter enclosure, or to an exposed nonflexible metal service raceway, or connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor*
  - b. At the disconnecting means for a building or structure that is supplied by a feeder or branch circuit, be electrically connected to the metal enclosure for the building or structure disconnecting means, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor*
- (5) The terminals shall be listed as grounding and bonding equipment.*

*Exception: In existing buildings or structures if any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), and 820.100 exist, installation of an intersystem bonding termination shall not be required. An accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors shall be permitted at the service equipment and at the disconnecting means for any additional buildings or structures that are supplied by a feeder or branch circuit by at least one of the following means:*

- (1) Exposed nonflexible metal raceways*
- (2) An exposed grounding electrode conductor*
- (3) Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding electrode conductor to the grounded raceway or equipment.*

*Informational Note: See 770.100, 800.100, 810.21, and 820.100 for intersystem bonding and grounding requirements for conductive optical fiber cables, communications circuits, radio and television equipment, CATV circuits, and network-powered broadband communications systems, respectively.*



***(B) Other Means.*** Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (1/4 in. thick × 2 in. wide) and of sufficient length to accommodate at least three terminations for communications systems in addition to other connections. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector. If aluminum busbars are used, the installation shall comply with 250.64(A). The busbar shall be connected to the grounding electrode system by a conductor that is larger of the following

- (1) The largest grounding electrode conductor that is connected to the busbar*
- (2) As required to permitted in 250.94(A)*

*Exception to (A) and (B) Methods for bonding intersystem bonding conductors are not required where communications systems are not likely to be used on a building or structure.*

*Informational note: The use of an IBT can reduce electrical noise on communications systems.*

- The parallel sections in Article 770 and Chapter 8 were harmonized with the changes to the 250.94 and clarified.

For users wishing to reference the NEC, it is important to start at the appropriate Article in Chapter 7 or Chapter 8 of the code that includes Articles 770, 800, 805, 810, 820, 830, and 840. The Articles in Chapter 8 covering communications circuits cross reference and are currently in harmony with the other applicable parts of the code (including Article 250 for grounding issues).

However, not all the grounding rules of Article 250 are appropriate or necessarily apply to the low-power communications circuits. To accommodate the special bonding and grounding conditions for communications circuits, the independence of Chapter 8 is recognized in Section 90.3 of the NEC and the customized B&G rules for each media type (e.g., twisted pair, coaxial and optical fiber cables) provided in the articles of Chapters 7 and 8 .

### 25.3.2 Grounding Electrode Choices

The first choice for grounding communications cables (metallic sheaths, ground conductor or other metallic components) is to bond to the nearest available location on the system or to the power service conduit or grounding electrode conductor that is connected to the system, whichever results in the shortest run of grounding or bonding conductor.

Where an IBT meeting NEC 250.94 is available, then it should be used as the



first choice in all service drop locations. That IBT is connected to a ground electrode systems.

The grounding electrode system consists of a bonded-together assembly of all the following electrodes that exist at the premises or structure, including:

- **Metal Water Pipe** – A metal underground water pipe in direct contact with the earth for 10 feet or more (including any metal well casing effectively bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or sections or insulating pipe) to points of connection of the grounding electrode conductor and the bonding conductors.

Interior metal water piping located more than 5 feet from the point of entrance to the building shall not be used as a part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system.

Because of the large number of requirements that need to be met in order to utilize the cold water pipe as an NEC-compliant ground source, grounding through the water pipe it is not a preferred option. This practice is now deemed too complicated for a technician, and increases the risks of creating a non-effective ground connection. The NEC now stresses the bonding together of all available electrodes into a ground electrode system (e.g., mesh bonding schemes), and the preferential choice for grounding the power is to any point on that system.

However, in structures where the electrical panel is grounded to the cold water pipe, and no actual grounding rod is present, the technician may bond to the electrode bonding conductor from the panel to the pipe, but not the pipe itself. This procedure would effectively bond the NID to the PGE through the panel connection/meter connections.

**Note:** Primary Grounding Electrode (PGE) - Defined in the NEC as a conducting object through which a direct connection to earth is established. This connection to earth is usually a rod and is placed by an electrician at the premises. Connected to the PGE one will have the Primary Grounding Electrode Conductor (PGE), which is defined as the conductor used to connect the system grounded conductor (neutral) to a grounding electrode or grounding electrode system.

The alternate and preferred means for a connection to a ground electrode systems (earth) include the following:

- The **metal frame connector or structure**, where any of the following methods are used to make an earth connection:
  1. 10 feet or more of a single structural metal member in direct contact with the earth or encased in concrete that is in direct contact with the earth.
  2. The **structural metal frame** is bonded to one or more of the grounding electrodes as defined in NEC Section 250.52:

- 250.52-(A)-(2): **Metal Inground support structure** in direct contact with earth for at least 10 feet with or without concrete encasement (e.g., pilings, castings or similar structural metal).
  - 250.52-(A)-(3): **Concrete Encased Electrode** (see below)
  - 250.52-(A)-(4): **Ground Ring** (see below).
3. The structural metal frame is bonded to one or more of the grounding electrodes as defined in NEC Section 250.52:
- 250.52-(A)-(5): **Ground rod or pipe**
  - 250.52-(A)-(7): **Plate electrodes**.
4. 250.52-(A)-(6 or 8): Other approved (i.e., listed for the purpose) means of establishing a connection to earth. This may include underground tank and other piping systems that constitute an effective contact with ground (the earth) even though not directly bonded to a metallic water pipe system.
- **Concrete Encased Electrode** – A concrete-encased electrode described in the NEC as an electrode encased by at least 2 inches of concrete, and usually located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth. The electrode consists of either of the following:
    - *At least 20 feet of one or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 1/2-inch diameter.* The 20-foot requirement can be met with one continuous length, or multiple segments joined together with exothermic welding, steel tie wires, or other means that ensures an electrically effective and permanent bond.
    - *Consisting of at least 20 feet of bare copper conductor not smaller than No. 4 AWG.*
  - **Ground Ring** – A buried ground ring, described in the NEC as, “A *ground ring encircling the building or structure, in direct contact with the earth at a depth below the earth surface not less than 2-1/2 feet consisting of at least 20 feet of bare copper conductor not smaller than No. 2 AWG.*”
  - **Rod and Pipe electrodes** shall not be less than 8 feet in length and shall consist of the following materials (also see [Section 25.3.3](#)):
    1. Electrodes of pipe or conduit shall not be smaller than metric designator 21 (trade size 3/4) and, where of iron or steel, shall have outer surfaces galvanized or otherwise metal coated for corrosion protection.
    2. Electrodes of rods of iron or steel shall be at least 5/8 inches in diameter, nonferrous rods, or their equivalent shall be listed and shall not be less than 1/2 inch in diameter.

(See [Section 25.3.1](#) for a discussion on ground rod sizes and material choices.)

- **Plate Electrode** – Each plate electrode shall expose not less than 2 ft<sup>2</sup> of surface to exterior soil. Electrodes of iron steel plates shall be at least ¼ inch in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch in thickness.

Article 250.53 (D)-(1) of the NEC states: *Continuity of the grounding path or the bonding connector to interior piping shall not rely on water meters or filtering devices and similar equipment.* Connections to water pipe electrodes must be made at the point where normal maintenance of meters and pumps or the installation of plastic water meters or insulating pipe sections for reducing vibration will not interrupt the grounding circuit. Insulated sections of pipe must be bypassed with a No. 6 copper bond wire (after consultation with the property owner) to maintain continuity and common grounding of the interior piping section.

In addition, the NEC requires that the communications ground, the power ground, and the interior metal water piping always be bonded together even though the underground portion is plastic or metal. Article 250.94 (*Intersystem Bonding*) of the NEC requires an accessible means to be provided at the power service for intersystem bonding. This may consist of one of the following:

- Exposed nonflexible metallic service raceways
- Exposed grounding electrode conductor
- Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding conductor to the service raceway or equipment.

Where the elements of the grounding system do not exist, standard ground rods may be used for grounding communications facilities. It is essential that the power and communications grounds be common and bonded, and that they also be bonded to interior metallic water piping even though the water piping may be deemed unacceptable as a grounding electrode.

If metallic members of cable sheath and grounding conductors of the protector circuits are required to be grounded under NEC 770.93, 800.90, 805.93 or 820.93 or other sections, the grounding conductors shall meet the following

1. The grounding conductor shall be insulated and shall be listed as suitable for the purpose.
2. The grounding conductor shall be copper or other corrosion-resistant conductive material, stranded or solid.
3. The grounding conductor shall not be smaller than 14 AWG.

4. The primary protector grounding conductor shall be as short as practicable. In one- and two-family dwellings, the primary protector grounding conductor shall be as short as practicable, not to exceed 20 feet in length.

**Note:** For the purposes of the first three list items above, the term “grounding conductor” refers to both the bonding conductors and communications grounding electrode conductor shown in Figure 25-1.

Where the necessary elements of the grounding system do not exist, standard driven ground rods may be used for grounding communications facilities. It is essential that the power and communications grounds be common and bonded, and that they also be bonded to interior metallic water piping even though unacceptable as an electrode.

Where connection to the power MGN<sup>4</sup> or an intersystem bond termination point is not available or is not permitted, then a communications ground rod or ground bed may be required for the communications facilities. A single ground rod may be sufficient or a ground bed is often preferred where several (i.e., 3 or more) 8-foot ground rods are driven and interconnected as shown in [Section 10.6](#) and [Figure 10-17](#).

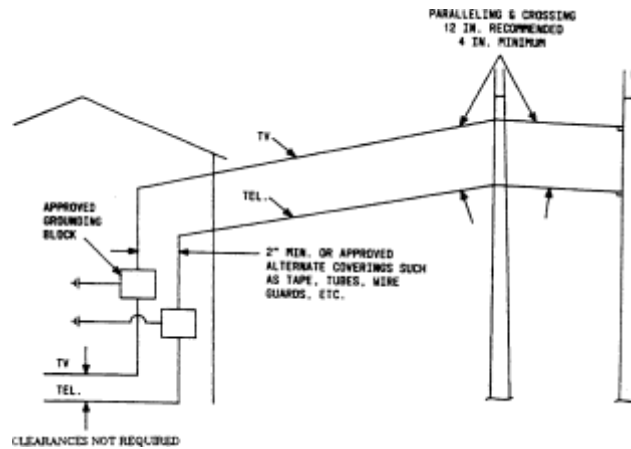
**Note:** Multi-Ground Neutral (MGN) - This is a type of utility power system where the neutral is consistently present along with the current carrying conductors and is grounded to an earth ground at specified intervals (4 or 8 grounds per mile).

The choice of one, two or three ground rods is based on:

- Local soil conditions - If soil resistivity in the area is well known to be low from previous measurements, knowledge/experience, then a single 8-foot ground rod (5/8 inch diameter) is usually more than sufficient for grounding of the communications circuit.
- NEC code - Under NEC Section 250.53(A)(2), a supplementary rod is required unless a single rod is known to provide resistance to earth of 25 ohms or less. Specific rod or general area measurements or documentation can provide evidence of sufficiently low resistance.
- Network or circuit demands - For situations where soil resistance is high or where a particularly good ground is necessary for the communications circuits, installing a ground bed of 3 ground rods shall be sufficient (see [Chapter 10](#)).

Typical communications attachments to poles and subscriber buildings are illustrated in Figure 25-3.

**Figure 25-3 Communications Drop Wire Clearances and Grounding**



### 25.3.3 Ground Rods – Recommended Materials, Designs and Diameters

The first sentence of NESC Rule 094 covering Grounding Electrodes contains the key functional performance objective for this discussion and chapter – “...*The grounding electrode shall be permanent and adequate for the electrical system involved...*” A review of the more relevant NESC and NEC safety code requirements finds the following.

From NESC - Rule 094B

- 1/2 inch diameter for the copper clad steel and stainless steel rods
- 5/8 inch diameter iron, zinc-coated (galvanized) steel, or steel rods.

From NEC at residences - Sections 800.100 and 250.52(A):

- 5/8 inch diameter stainless-steel, copper-coated steel, zinc-coated steel - unless the rod is listed
- 8 foot rod specified in Section 250.52(A)(5)
- With permission under Section 800.100(B)(3) to use smaller (1/2 inch diameter) and shorter (5 foot) rods for communications circuit grounding at residences.

The most widely used ground rod is an 8-foot x 5/8-inch copper-clad stainless steel rod. Other rods are explicitly permitted within NESC Rule 094, including 5/8-inch diameter galvanized steel and iron pipes, providing the alternate ground rod:

- A. Possesses good electrical conductivity to provide a low-resistant, low-impedance connection to earth,
- B. Is mechanically robust to enable it to be driven in different soil types (including rocky soils) without bend or significant damage to the rod,
- C. Is able to withstand repeated fault and surge currents, and
- D. Is resistant to corrosion.

An exception to Rule 094B2a allows different diameters and configurations if a qualified engineering study is performed. Under such allowances, the shorter 5-foot x 1/2-inch ground rod noted in the NEC has been used and found acceptable for grounding communications circuits, but the longer 8-foot rod should be used if the communications and power circuits are both grounded through the same rod.

The electrical properties of the grounding electrode and for the effective ground connections needed for communications circuits, cable shields/armors and any associated tracers/toner wires are less stringent than any grounding electrode connected to a power delivery and distribution system where the currents and voltages that may flow are much larger and a more regular occurrence. Power ground connections are often required to safely handle significant currents on neutral and grounded power conductors.

The communications industry currently prefers the use of 5/8-inch copper-clad steel, and stainless steel rods based on the mechanical strength of steel rod for driving into most soil types, and the corrosion resistance of these rod types from studies and field experience over the last 30+ years. The 5/8-inch size is based on (1) exceeding the applicable NESC/NEC codes and regulations, and (2) sufficient diameter and strength of rods so they do not bend or fracture easily when driven; particularly when longer lengths (10-feet, etc.) need to be driven into many different soil and ground types. Larger diameter rods, e.g., 3/4-inch, should be used for areas known to be of harder/rocky soil types.

#### 25.3.3.1 Current (NESC 2023) Issues

##### 2017 Reprise -

Several industry discussions around the current NESC rules have revealed that there are practical issues around identifying the acceptable rod diameters and materials to be used.

- **Rod Diameters** – There are several rod diameter values used in describing the products which may confuse users between trade size vs. nominal size vs. actual measured size.

- For example, the stainless steel core of a typical “5/8 inch” trade size rod is actually only a 0.535-inch diameter (not the 5/8 = 0.625 inch implied by the trade size given) with a 10-15 mil thick copper cladding by electroplating methods to have an actual measured diameter of 0.555 to 0.565 inch.
- For galvanized rods made from the same 0.535-inch steel cores where the zinc protective coating is applied by dipping, the thickness of the coatings is usually thicker to create an actual diameter of 0.600-0.614 inch.
- The threaded sections of the rod are formed by building up further metallic thickness for the thread formation and for those end sections only the diameter may approach the 0.625-inch (5/8-inch) value.
- **Material choices** – Field data from the National Association of Corrosion Engineers (NACE) and Naval Research studies indicate the iron and steel pipes/ rods are more susceptible to corrosion than the stainless steel and steel rods coated with protective layers of copper or zinc. The field data on specific relative corrosion rates between stainless steel, copper clad, and zinc coated (galvanized) is complicated by the multiple variations of local electrochemistry between rods, soil types, and groundwater, as well as the influence of physical conditions such as soil-rod surface interface and breaks or damage to coatings during driving of the rod and attachment of connection hardware.
  - There are anecdotal reports on long-term successful (i.e., with low corrosion) use of galvanized rods and posts in buried situations. Equally, there are anecdotal reports from Florida showing dramatic corrosion differences in ground rods placed in adjacent areas to highways.

As noted above, a ground rod needs to possess good electrical conductivity, be mechanically robust, be able to withstand repeated surge currents and be corrosion resistant. Both 5/8-inch trade sizes and actual 0.625-inch diameter rods can meet these functional performance requirements for communications circuit grounding. Current telecommunications industry preferences and product specifications are for using 5/8-inch copper-clad steel and stainless steel rods as the standard rod design.

For most telecommunications applications, a 1/2-inch diameter rod would also be sufficient from a conductivity standpoint, but the 5/8-inch rod is the preferred standard from both a strength consideration and for being able to accommodate all types of installations, soil types and environments. This choice of the 5/8-inch product as documented in industry specifications (e.g., AT-7181, NEMA GR 1, GR-3174, ATT-TP-76416 and 1992 TVPPA Design & Construction guidelines) is primarily based on strength of steel rod for driving into most soil types (including rocky areas), and the corrosion resistance of these rod types from studies and field experience over last 30+ years. Any difference between actual, trade, nominal, and minimum rod

sizes are best addressed during the updating of these product specifications.

### 2023 Update

Several NESC and NEC code discussions (within formal subcommittee meetings and official working group meetings) over the last 5 years have made clear that the functional performance requirements necessary to make a reliable and effective ground rod include other features beside the electrical resistance between rod and soil. The current NESC Rule 094B2 contains the following statement in the charging section:

*The following made electrodes are considered equivalent for the purpose of this rule.*

*Other diameters and configurations may be used if their suitability is supported by an engineering study.*

Grounding and bonding are used in telecom installations to accomplish the following:

1. Limit potential differences between conductive parts caused by electrical disturbances such as power faults, power crosses, lightning crosses, induced voltages, and electrostatic discharges.
2. Provide an engineered fault current path of sufficient ampacity (current carrying capacity) and low impedance to permit overcurrent devices to operate (telecom devices as well as power devices on joint structures)
3. Reduce noise and electromagnetic inference produced by, or introduced on to, telecommunications installations and facilities
4. Enhance the immunity of the telecommunications installation, equipment, circuits to effects of foreign noise (electrical) and electromagnetic interference
5. Contribute to reliable equipment operation by having a stable and consistent ground potential.

The adequacy of a grounding electrode needs to be evaluated by consideration of not only the ground resistance, but also other properties such as (1) the fusing current capabilities of the electrode in respect to expected fault current and protection devices of a system, (2) the corrosion resistance of the materials, and (3) physical robustness of the electrode under installation stresses.

A review of the needs within the communications industry, the desirable or recommended ground resistances were found to be:

- Individual Connection - Maximum resistance for the connections that bond wires to terminals, across splices, and so forth for solidly bonded connections were typically cited between 5-100 milliohm



range. The precise value depends on specific connection points being discussed and locations (inside building). These value were found in product requirements/specifications standards for evaluating terminal blocks and other grounding/bonding hardware.

- Main Ground Connection - Recommended resistance to ground (earth) or to the Main telecom facility ground inside buildings is less than 1-5 ohms as an objective.
- Inside Central Office/Switching Office - Within a central office, less than 1-2 ohms value is desirable, while less than 5 ohm requirement is acceptable.
- OSP ground connection - A maximum value of 10 ohm for an outside plant connection to earth (ground) is deems acceptable.

An oft-cited minimum value of 25 ohms is still present in the current NEC code (in 250.53A2 Exception); however, since 2014 the NEC revised that 250.53 section to have a default of using two electrodes with an allowance (exception) to just use one electrode if the resistance is less than 25 ohms. The move away from using the 25 ohms as the prescribed value occurred after field measurements determined that the 25 ohms was not routinely found in places and the variability of the resistance was great from day to day, weather, rain, watt table level, soil type & compaction degree, and other such factors.

The made electrodes described in NESC Rule 094B2 have been shown to provide effective grounding for the applications and conditions described from field experience.

Using the equations from IEEE 142 - *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems*) one can calculate equivalent resistance for the different electrode systems relative to a 5/8inch diameter driven rod shown below.

**Table 25-1 Made Electrode – Ground Resistance Comparison**

| Made Electrode<br>(in 100 ohm-feet soil)  | Ground Resistance<br>(percentage relative to 5/8 rod) |
|-------------------------------------------|-------------------------------------------------------|
| 8ft long, 5/8 inch diameter rod           | 0                                                     |
| 8ft long, 1/2 inch diameter rod           | 103%                                                  |
| 100 feet of wire                          | 16%                                                   |
| 11 feet of buried wire                    | 99%                                                   |
| Strip (10 ft long 5ft <sup>2</sup> )      | 76%                                                   |
| Strip (7 feet long, 3.5 ft <sup>2</sup> ) | 90%                                                   |
| Plate (2 sq. ft. --> 6.77 inch radius)    | 189%                                                  |
| Plate (3.7 sq. ft. --> 13 inch radius)    | 101%                                                  |

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Apart from the value of the ground resistance, the criteria for evaluating different ground electrode performance will include properties such as:

- Mechanical strength – One needs to consider the ease of installation without damage to the connection or electrode or electrical bond to the soil.
- Mechanical robustness - One need to consider the capability of maintaining the mechanical strength and electrical bond integrity of the electrode under soil burial conditions.
- Corrosion resistance - One need to consider the corrosion resistance of metal surface of the electrode under moist soil conditions.

Calculated resistance for driven rods - The length of the rod between 5 and 12 feet has a larger effect than the difference between 1/2 and 5/8 inch diameters. The calculated resistance for the 1/2 inch and 5/8 inch diameter driven rods are within 5% of one another.

Wire and strip electrodes versus driven rods. - The ground resistance values for 100 feet of wire are much lower than that for driven rods. The calculated resistance for wire or strip electrodes is more sensitive to length of wire or strip than to the precise depth or diameter of the wire or /thickness of the strip. Since the wire and strip electrodes are more susceptible to corrosion over time and physical damage during installation and burial, the NESC rule requires 100 feet of wire and 10 feet of strip which seems more than equivalent to 5/8 inch driven rod based on resistance calculations alone.

Other mitigating factors for the wire/strip electrode is the surrounding soil being less uniform and less well bonded than soil packed firmly around a driven rod, as well as since the wire and strips need only be buried 18 inches deep. Such shallow depths are less effective depending on frost line and ground water level than rods driven 8 feet deep.

Plates Plate electrodes are buried 5 feet deep which is well below most frost lines and the depth would help with lowering the ground resistance to soil. That buried depth is assumed to be the reason that the 094B criteria is a little less than the ground rod based solely on calculated resistance.

Considering the driven rods currently listed in Rule 094B2a and the communications industry experience and performance specifications, the conclusions for driven ground rods could be summarized as

- (1) The rod shall be zinc-coated steel, copper-coated stainless steel, copper, or stainless steel and shall have a diameter of not less than 12.7 mm (0.5 in).

**Note 1:** To meet the minimum 0.5 inch requirement, driven rods should be at least 5/8 inch trade size. For example, the diameter of a nominal 5/8 [0.625 inch] copper-coated steel rod varies from 0.555 to 0.565 inch whereas for a zinc-coated steel rod it varies from 0.539 to 0.555 inch.

**Note 2:** The use of aluminum and iron rods as electrodes are not considered to meet the general performance and corrosion requirements of 094A.

- (2) Driven rods may be sectional but the total length shall be not less than 8 feet (2.45 m).
- (3) Longer rods or multiple rods may be used to reduce the ground resistance. Spacing between multiple rods should be not less than 6 feet (1.8 m).
- (4) The driven depth shall be not less than 2.45 m (8 ft). The upper end shall be flush with or below the ground level unless suitably protected.

With general caveats or exceptions such as:

- Other diameters or lengths or configurations may be used if their suitability is supported by a qualified engineering study.
- Where rock bottom is encountered, driven depth may be less than 8 ft, or other types of electrode may be employed.
- When contained within pad-mounted equipment, vaults, manholes, or similar enclosures, the driven depth may be reduced to 7.5 ft.

#### **25.3.4 Reference Materials Used for Section 25.3.3 Discussions**

1. *Underground Corrosion Study* – NBS Circular 579 (1957).
2. *Field Testing of Electrical Grounding Rods* – NACE (National Association of Corrosion Engineers) & Naval Civil Engineering Lab R660 \*1970).
3. *National Electrical Grounding* research project – T. Lindsey (2007).
4. *Experimental Evaluation of the Corrosion Performance of Copper bonded and Galvanized Grounding Electrodes* – IAEI News (2008) – F.D'Alessandro (SMIEEE) & B. Baumgartner (Erico).
5. GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles*, points to traditional Bell System specification AT-7181 (D Ground Rod).
6. AT&T *Bonding and Grounding Practice* denoted as ATT-TP-76416 – Section 1.4. on Ground Rods.
7. *TVPPA Design and Construction Guidelines for Design and Transmission* (1992).

### 25.3.5 Grounding of Metallic Components of Fiber Cable

The metallic components of optical fiber cables can include aluminum and steel based armors or shields, reinforcement strands, as well as tracer and toner wires integrated into cable jackets and separate wires located inside or immediately adjacent to conduit and cable runs.

These metallic (i.e., conductive) elements on which no current/voltages are to be expected under any normal operational circumstances need to be grounded or isolated at the residence under NEC (770.114) and NESC rules. The tracer or toner wire may have a signal placed on them during location operations, but in general no voltages/ currents should be present. However, such wires or shields are a long piece of ungrounded metal in the ground that constitute a conductive path for the lightning or Ground Potential Rise surges to travel along the plant and possibly enter into the house. The NEC concern is that these metallic members can be a means to bring foreign voltage/current from a power fault or lightning event inside the house and create a safety or fire (arc) risk.

- NEC Rules 770.49, 770.93 and 770.114 require that the metallic shields, armors, metallic conduit or tracer wires (“non-current-carrying metallic member of optical fiber”) be either grounded or isolated at the point of entrance to the building.
- NEC 770.49 (Metallic Entrance Conduit Grounding) requires grounding of the metallic shield at the entrance point to the home. Section 770.49 has the equivalent parallel sections (800.49, 805.49, 820.93 and 840.49) covering other network configurations using metallic conductor pair and coaxial cables.
- NEC 770.93 and 770.114 (Grounding or Interruption of non-current-carrying metallic Members of Optical fiber Cables) applies to toner/tracer wires that are allowed to be grounded or interrupted with an isolation joint.

*“In installations where an optical fiber cable is exposed to contact with electric light or power conductors and the cable enters the building, the non-current-carrying metallic members shall be either grounded as specified in 770.100 or interrupted by an insulating joint or equivalent device. The grounding or interruption shall be as close as practicable to the point of entrance.”*

**Note:** The NEC phrase “exposed to contact with electric light or power conductors” implies that if the optical fiber cable is not joint-buried or in close proximity (service wires coming from same pole or from adjacent pedestals), then there are no NEC safety concerns regarding the toner wire (metallic member). However, there is still the possibility of unwanted current (induced) flowing on the tracer wire if it is in parallel with the power drop and grounded at both ends, even if it is not joint-buried or in close proximity. Therefore, as a general principle to develop

best grounding/bonding practices, it should be assumed that the communications cable may possibly be directly exposed to power surges in a power cross, fallen pole or excavation scenario, or through induction situations.

A corrugated cable shield or armor should be treated like a Rigid Metal Conduit (RMC) or Intermediate Metal Conduit (IMC) and be grounded where it enters the building. However, with other items such as the toner/tracer wires, foil shields and metallic strength members, either grounding or isolation (insulating joints) are viable options, with isolation being preferred.

To meet the requirement for being "...Grounded..." one would normally connect to the intersystem bond (IBT) if present, or to the ground bar in a NID if present and practical.

The alternative is to "...interrupt by an insulating joint...", which is accomplished with breaking the toner wire so there is no electrical connection. This would be best achieved by cutting the toner wire and covering the cut end with electrical tape. For a separable toner/tracer wire, it could be cut, folded back, and taped to the end of the buried fiber cable. Such a configuration will prevent any risk of stray current entering the house through the toner wire.

**Note:** Isolate versus insulate – The term "isolate" as used in the NEC has a precise meaning when applied to a location, in that the location is "not readily accessible to persons". The term "isolation joint" as used in the telecom industry means the splice case or joint used in the CO to break the shield of an OSP cable and help ensure stray currents on the shield do not get into CO equipment. The term "insulating joint" as used in NEC Rule 770.93 means "...not being electrically connected...". If a term is not defined in the NEC article where it is used, or in Article 100, then one looks to a general dictionary where we find that insulated is "the action of separating a conductor from conducting bodies by means of nonconductors so as to prevent transfer of electricity, ...".

The insulating joint or interruption joint should be close to the NID, if practical. That would mean keeping the connection and ground connection for the toner wire at the last pedestal or handhole; that access point is needed for when a toner signal is placed on the wire during location work.

One should not need or desire to open the fiber cable in a straight-through (no splice) pull box only to ground the armor, shield or tracer wire. One should not need to drive a ground rod for the sole purpose of grounding a tracer wire. However, if there is a splice case or connection point within this access point (pedestal, handhole, cabinet), one will usually have a ground rod or ground bus bar to which a bond can be made for grounding the shields, armors and tracer wires.

### 25.3.6 Grounding of Antenna Lead-In and Other Components of Local Communications Antenna

As wireless networks expand greatly, the use of antennas that serve single residences (building) create applications where electrical coordination issues arise as communications cables and grounding/bonding conductors are connected between the receiving/transmitting antenna, the NID box mounted on the outside of the building (house), and the interior/inside customer equipment powered through outlets inside the house.

The initial assumption that an antenna-based system should be under Section 810 can be debated since the wireless telecommunications service from a local antenna is not strictly *radio and television receiving equipment* under the Article 810 scope statement.

NEC Article 810

*810.1 Scope. This article covers antenna systems for radio and television receiving equipment, amateur and citizen band radio transmitting and receiving equipment, and certain features of transmitter safety.*

However, there are other NEC sections that some users may deem to be “more applicable” for these WiFi communications systems, including:

- Sections 800/805 – If 810 is not applicable, then one can default to the general section 800 for communications systems. In general protective devices would not be required since the cable from the antenna would not be exposed to AC and would be located within a *block*. However, the antenna and wireless equipment is exposed to AC power at the point at which it is plugged into an outlet inside the building. The NEC concept of “block” is a city block that would be afforded some electrical protection from the surrounding tall buildings under the protection principle of the *rolling sphere of protection* (see NFPA 780 and other industry guides such as the Lightning Protection Guide from [www.dehn-international.com](http://www.dehn-international.com))
- Section 820 – This section may apply given the coaxial cabling that is used to bring signals to/from the antenna. However, these parts of Article 820 coaxial cable is supposed to cover “premises coaxial cables” and was not designed for outside cables that run to and along the outside of the building as well as run away from the building to an antenna that may be located on a separate mast (i.e., not attached to the building).

Excerpts from 820.100 – Cable Bonding and Grounding

*The shield of the coaxial cable shall be bonded or grounded as specified in 820.100(A) - (B)*

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*Exception: For communications systems using coaxial cable completely contained within the building (i.e. they do not exit the building) or exterior zone of protection defined by a (46m) 150 ft. radius rolling sphere and isolated from the outside cable plant, the shield shall be permitted to be grounded by a connection to an equipment grounding conductor as described in 250.118.*

*Connecting to an equipment grounding conductor through a grounded receptacle using a dedicated bonding jumper and a permanently connected listed device shall be permitted. Use of a cord and plug for the connection to an equipment grounding conductor shall not be permitted.*

- Section 840 and its referenced sections – Also considered to apply because these antennas and wireless systems are often powered from inside the customer premises. These WiFi services will be interconnected (hardwired) to set-top boxes, gateway devices, video displays (TV), and computers.

The Section 820.100 Exception noted above addresses *premises coaxial cable* only. It does not apply to premises coaxial (both inside and outside the building) that connects to outside plant. Basically, the Exception was designed to cover CATV- type premises coaxial cable on the customer side of the grounding block. One needs to distinguish that the entire outdoor antenna system installation is under the scope of Article 810 only, not Article 820; thus, the changes in Article 820 are not applicable. In the future, the NEC code will hopefully become more specific on how to handle the antennas, circuits and grounding components and interconnections for mobile and WiFi communications systems.

Antenna lead-in wires under Article 810, coaxial cable under Article 820, and twisted pairs under Article 805 all need to be grounded under the 2023 code. There are some allowances for masts and supporting hardware that need not be grounded (e.g., under 810.15) if they are protected as per NFPA 780 protection schemes as defined by the rolling sphere (ball) protection model.

The NEC (and the NESC) both explicitly state they are “not design manuals”, even though they are sometimes used that way by certain users. Therefore, without clear direction from the safety codes, the choices of the functional performance criteria of equipment and the grounding and bonding practices for these WiFi services should have an objective to avoid configurations that would more easily allow or enable lightning or other power surges to pass into the premises and CPE without some mitigation efforts.

A combination of ground electrode systems, grounding blocks, and primary and secondary protection is necessary to obtain network reliability, safety and a high level of performance demanded for these services. These design

choices for grounding and electrical protection need to be driven by conservative protection designs and build off field experience of service providers.

Given the above discussion, if an entire installation (WiFi antenna, outside cables, NID and indoor equipment) lies within the protection/exclusion zone under the 150 foot radius rolling sphere, then one possible 2023 NEC-compliant grounding configuration could include:

- A. An NEC Article 250.118-compliant equipment grounding conductor inside the premises structure (e.g., the coaxial cable and equipment connection inside the dwelling unit) with,
- B. No need for other ground connections in the outside segment of the antenna or to the coaxial cable connected to the antenna.

However, such a simple NEC code compliance approach will not provide a universal design to address functional performance and reliability concerns such as:

- Coordinated electrical surge and lightning protection between outside components (antenna, NID, cabling) and inside building devices that are plugged into a variety of protected, unprotected, grounded or ungrounded power outlets.
- Intersystem connections to other service architectures at the premises that may or may not have OSP exposure (and without the rolling sphere protection zone).
- Development of tables and/or education on the calculations required for where the new rolling sphere exclusions can be applied as well as educating local inspectors unfamiliar with the application of such rolling sphere concepts and rules to communications systems.

Based on this discussion, a current recommended plan for a WiFi installation serving a single residence (building) would be to use grounding and splicing blocks for current conductors entering from the bottom with the following configurations:

1. Ground the antenna structure unless it is within the protection/exclusion zone offered by the house or other structures, i.e., under the 150-foot radius rolling sphere of protection as per NFPA 780. To achieve this ground connection, it may be convenient to run a ground conductor (bonding conductor) wire from the antenna to the busbar or ground block inside the NID.
2. Use a shielded cable from outdoor antenna to NID – A cable with a transmission capability of Cat 5e or better would be preferred for better service delivery.
3. Ground connection from NID to main ground electrode (ground rod).
4. Outdoor/indoor rated unshielded cable from NID to interior equipment.



## 25.4 Basic Grounding Methods and Procedures

1. A technician must ground the NID protection to the primary grounding electrode (e.g., power ground rod, electrode grounding conductor) with a copper grounding wire. Typically, a #6 AWG copper conductor is used for the connection to the grounding electrode or IBT and will cover all situations. Although smaller gauge conductors (e.g., #10 AWG or #14 AWG conductor) are permitted by the NEC, they are normally reserved for the bonding conductors inside NID closures or internal to equipment that bond the protection elements to the ground bar or terminal inside the device.

**Note:** This section is modeled on information found in the GR-49 specification for Network Interface Devices (NIDs) and, therefore, uses NID as the example demarcation point and in the illustrations. The description and procedures here are generic for other facilities such as Building Entrance Terminals (BETs).

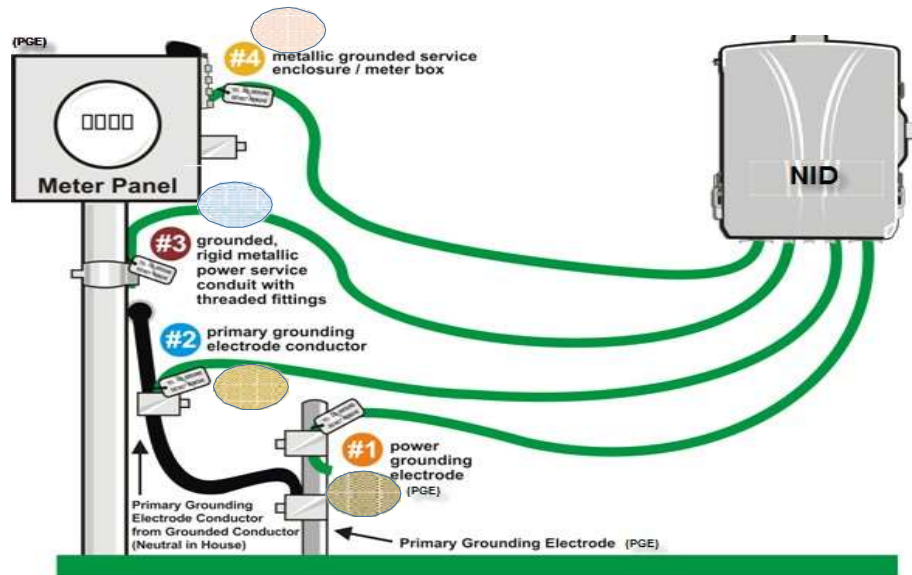
Grounding wires with a smaller gauge than #6 AWG (i.e., #10, #12, #14) require physical protection such as found inside a closure or insulation conduit or U guard where the possibility of damage to the exposed wire exists (e.g., wire installed where it can be hit with a weed trimmer).

2. Technicians must follow local practice regarding work ticket generation to locate or mark-out the area to prevent damage to underground facilities prior to ground rod installation.
3. The NID closure must not be placed any closer than 12 inches to the AC power meter.
4. A telecommunications grounding electrode wire cannot exceed 20 feet, regardless of gauge, between the NID and the primary grounding electrode.
5. Technicians must run a telecommunications grounding electrode wire as straight as possible, avoiding any sharp bends (any bends made must be sweeping curves).
6. If the wire distance between the NID and the grounding point exceeds 20 feet, the technician must perform the following:
  - a. Install either (i) a 5-foot x 1/2-inch or (ii) an 8-foot x 5/8-inch ground rod within 20 feet of the NID. A ground rod should not be within 6 feet of any other ground rod.
  - b. Bond the newly installed ground rod to the primary grounding electrode with #6 AWG grounding wire.
  - c. Connect the NID protection to the newly installed ground rod using #10 or #6 AWG telecommunications grounding electrode conductor.
7. If multiple ground rods exist, the technician must bond all ground rods together with a #6 AWG grounding wire.

8. The grounding wire should be installed in one continuous length without a splice. However, splices are permitted if they are irreversible (i.e., compression connectors).
9. If two dissimilar grounding electrode conductors are in direct contact with each other (e.g., copper and aluminum), a fine coating of conductive anti-oxidation grease (e.g., No-Ox) must be used on the connecting surface. This does not apply to the clamps themselves.
10. Any protection device (i.e., NID) must have only one (1) grounding point.
11. If the technician needs to run a grounding wire through a wood frame structure, then the grounding wire must be run through a noncombustible, insulating tube/ sleeve.
12. If a grounding wire is placed interior to a home/structure (crawl space, basement, etc.), that wire must be green in color. This requirement includes grounding wires that run in an interior to exterior application.

**Note:** The Order of Preference (Options 1 through 4) shown in [Figure 25-4](#) is built around obtaining the shortest connection (with the lowest resistance/impedance) to the ground electrode system. However, that order of preference should be considered as only one possible general choice. The preferential order may vary based on local environmental conditions, traditional practices, limited access to ground rods and connections, and other local factors.

For example, the IBT shown attached to the meter panel (#4) may be more readily accessible, available and connected to compared to either (a) a buried ground rod with a top end deformed by the hammering/driving process, or (b) a primary power grounding conductor for which no permission has been given to attach. Connecting to a recognized and designated IBT attached to the meter panel or power service conduit will often take precedence over other connections that need to be made to the power supply grounding system. The sequence A-B-C-D shown in [Figure 25-4](#) reflects a possible choice order based on least contact with power grounding conductor or ground rod.



### 25.4.2 Grounding Clamps

When making a grounding connection, technicians must ensure that:

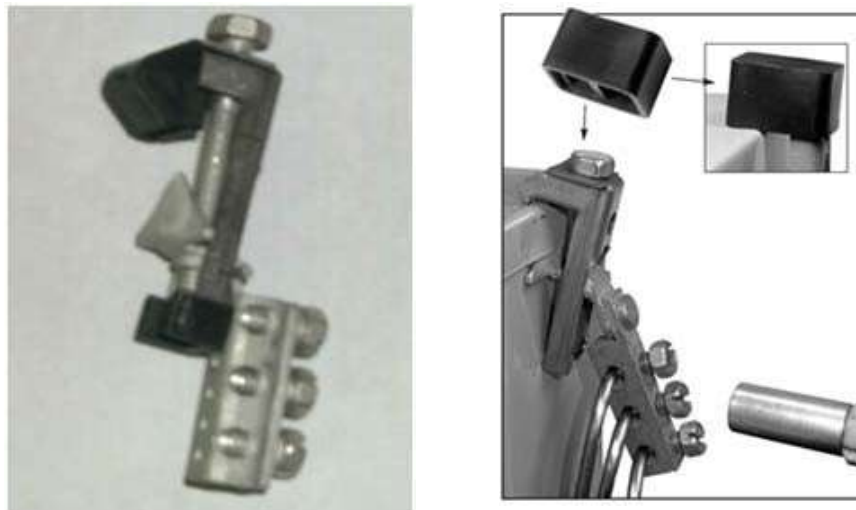
- The proper clamp is used, i.e., a listed connector with appropriate conductor size, matching design, and anti-rotational fittings
- The surface of the grounding point is free from debris, corrosion, paint, or any other current impeding material
- The connections are tightened properly with adequate torque
- Only a single grounding connection is made to avoid ground loops.

**Figure 25-6 Ground Rod Clamps**



**Figure 25-7 Grounding Wire Clamps****Figure 25-8 Threaded Metallic Conduit Clamps - Strap Clamps**

**Note:** The clamps shown have two extra flat washers which may be used for a small AWG grounding connection (i.e., tracer wire) in addition to the #6 or #10 AWG equipment grounding connection. These clamps may also be used for ground rod connections.

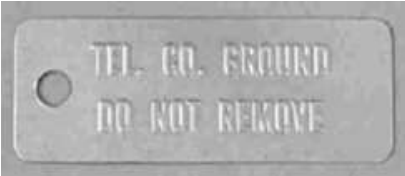
**Figure 25-9 Meter Box Clamps**

**Note:** The clamps shown are approved for use in all scenarios/ environments. These clamps must be used in all applications where meter box grounding is the best viable option. Do not drill the meter box.

## 25.5 Ground Tags

Grounding connections shall be tagged at or adjacent to the PGE. This requirement applies to grounding connections at the PGE and copper NID. The tag must be secured (e.g., zip-tied) to the grounding wire to prevent the tag from sliding or being detached.

**Figure 25-10 Typical Ground Tags**

| Indoor Tag                                                                          | Outdoor Tag                                                                          |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |

## 25.6 Grounding Requirements

The ground connection at the customer premises shall be established in one of the following ways (listed in approximate order of preference):

1. Connecting the NID to a primary grounding electrode rod. The communications grounding electrode conductor must not exceed 20 feet in length.
2. Connecting the NID to a grounding electrode conductor. The communications grounding electrode conductor must not exceed 20 feet in length, including the path to the PGE.
3. Connecting the NID to the grounded, rigid metallic power service conduit with threaded fittings leading to the metallic grounded service enclosure/meter box. The communications bonding conductor must not exceed 20 feet in length, including the path to the PGE.
4. Connecting the NID to the customer's metallic grounded power service enclosure/meter box using an approved meter box clamp. Technicians must assure that the placement of the clamp does not inhibit access to the meter. The telecommunications bonding conductor must not exceed 20 feet in length, including the path to the PGE. If there is a meter box clamp present with the capacity to terminate an additional grounding electrode conductor, technicians must use that meter box clamp and not place an additional meter box clamp.
5. Connecting the NID to an 8-foot x 5/8-inch telephone grounding rod (an acceptable option is to use a 5-foot x 1/2-inch). The rod must be placed at least 6 feet away from any other grounding rod and/or building lightning protection system. The telephone grounding rod must be bonded to the PGE with a #6 AWG copper wire. Though the bond's length is not restricted, the telecommunications grounding electrode conductor must not exceed 20 feet.

**Note:** Never place any equipment or wiring in a location that inhibits access to a company's equipment that is meant to be accessible. (Example: A meter box grounding clamp placed so the meter box cannot be opened without removal of the grounding connection.) Never remove the grounding clamp between the grounding electrode conductor and the primary grounding electrode rod. Technicians must add an additional approved grounding clamp to complete the connection.

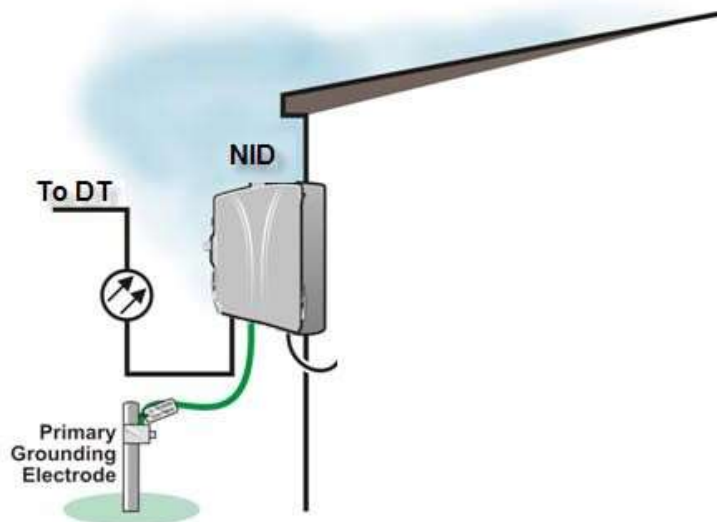
If no viable power grounding option exists, technicians must not install services and are required to refer the job to their immediate supervisor.

## 25.7 Grounding NIDs in Detached Structures

When installing service to a detached structure on the same premises (e.g., garage, pool house, workshop, etc.), all wiring is considered Customer Premises Equipment (CPE) and should be terminated on the customer side of the primary NID. If buried service drop is used for the extension, then the sheath members need to be grounded in the primary NID. No further grounding is required at the detached structure.

## 25.8 Verification of the Grounding and Bonding Connections

Figure 25-11 NID Installation



On every installation and/or maintenance order where a NID is either placed or replaced, the ground path should be verified. This verification can be done through two (2) methods, depending on the grounding method used:

- Sidekick or Volt-Ohm Meter continuity reading between the NID and the grounding point (preferred).

The grounding path must pass one of these two tests to be considered a “good grounding path.” In cases where the grounding path does not pass, technicians must correct the condition and retest the grounding path prior to completing the Service Order or Maintenance Ticket. In each case, verify that:

- The grounding connection has been placed in accordance with the guidelines presented in this document



- Both connection points are tightened accordingly
- Any residue (e.g., paint, rust) has been scraped or sanded off the connection point(s), and a firm metal-to-metal connection exists.

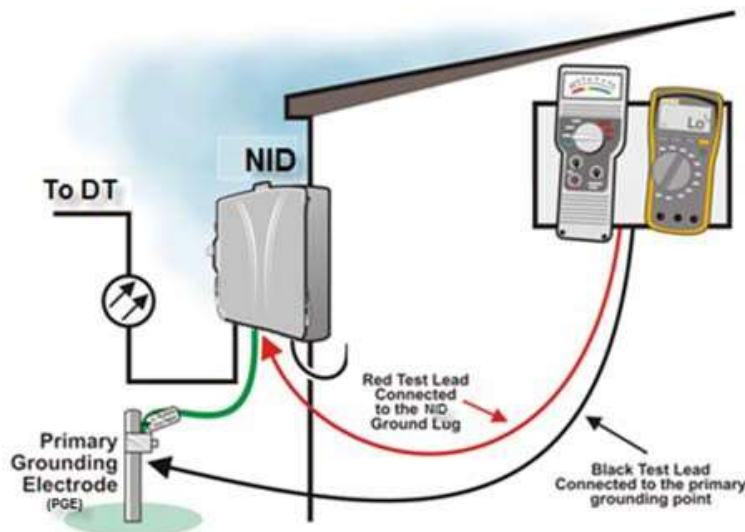
Prior to performing either of the methods described below, technicians must ensure that:

- The grounding connection is placed in accordance with this document
- No customer wiring is connected to the NID.

### 25.8.1 Test Method 1

This test is the preferred method for grounding path verification and must be used in every case where the technician has immediate access to both the NID and a selected grounding point with a test meter. This test may be performed with either a Volt-Ohm meter or equivalent field test tool.

**Figure 25-12 Test Method 1 for Grounding Continuity Check**



### 25.8.2 Test Procedure:

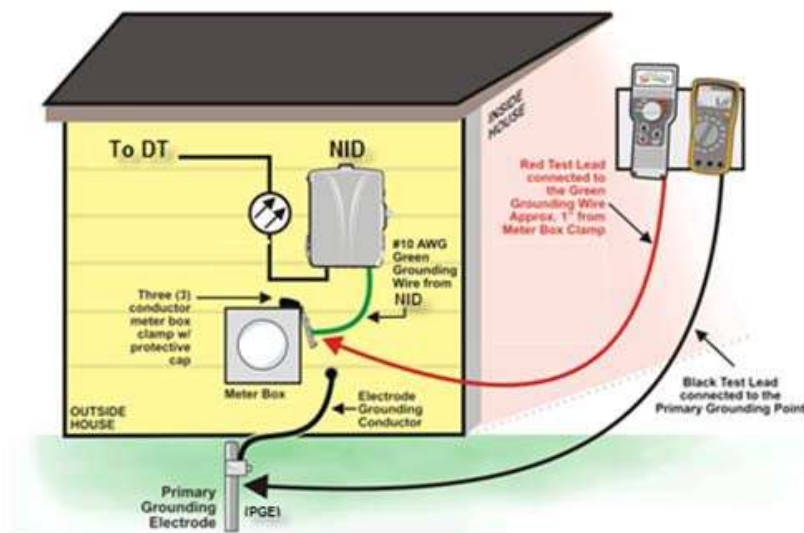
1. With the NID technician door open, connect the Red Lead to one of the NID grounding lugs.
2. Connect the Black Lead to the primary grounding point (if needed, technicians may use a temporary bonding cord to reach the PGE).
3. Turn the resistance test function:
  - Volt-Ohm Meter: Turn the dial to the Continuity (0) position.
4. Check the meter to see if continuity exists. The meter should not read an open circuit and should indicate a completed circuit for the grounding path.

**Note:** If the grounding path does not pass the test, it must be corrected prior to completion of the Service or Maintenance Order.

### 25.8.3 Test Method 2

This test is to verify that a meter clamp has made adequate contact with the meter box to provide an acceptable grounding path. This test may be performed with either a Volt-Ohm meter or equivalent field test tool.

**Figure 25-13 Test Method 2 for Meter Box Connection**



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### 25.8.4 Test Procedure:

1. Connect the Red Lead to the #10 AWG Green Grounding Wire approximately 1 inch from the meter box clamp.
2. Connect the Black Lead to the primary grounding point (if needed, technicians may use a temporary bonding cord to reach the PGE).
3. Turn the resistance test function:
  - Volt-Ohm Meter: Turn the dial to the Continuity position.
4. Check the meter to see if continuity exists. The meter should not read an open circuit and should indicate a completed circuit for the grounding path.

**Note:** If the grounding path does not pass the test, it must be corrected prior to completion of the Service or Maintenance Order.

## 25.9 Grounding at Mobile Homes and Trailers

### 25.9.1 Overview

When installing service into a mobile home, trailer, or other temporary structure, the NID should not be mounted directly to the structure. Unlike permanent structures, the electrical service equipment (i.e., power meter) is not located on or in the mobile home, but is located near the mobile home at a service disconnect point. At the service disconnect point, the commercial power neutral conductor is grounded, and the mobile home's equipment grounding conductor and insulated neutral (grounded conductor) are bonded. This service disconnect point also serves as the Demarcation point.

The equipment grounding conductor is used to bond the chassis of the mobile home and all associated exposed metal. By having an insulated neutral, the chassis and exposed metal are not a return path for electrical loads. Therefore, the associated exposed metal does not become energized, except possibly under some fault conditions.

Because of these wiring differences, the NID ground must be connected to the common grounding system for the structure (i.e., Primary Grounding Electrode).

### 25.9.2 Grounding in Mobile Home/Trailers - NID Placement Considerations

Technicians must consider the available grounding options and rules when selecting a placement location for the NID. The location selected should minimize the length of the grounding conductor between the NID and the PGE. Some scenarios for aerial and buried applications are described below, with example schematics shown [Section 25.10](#):

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- Location of the Power Service Disconnect/Meter
  - Aerial fed on a stub pole or joint-use pole ([Section 25.10, Figure 25-14](#))
  - Buried to a post or mast ([Section 25.10, Figure 25-15](#)).
- On a mobile home stake
  - Aerial fed on a mast, stub pole, or joint-use pole
    - > Within 20 feet of the PGE ([Section 25.10, Figure 25-16](#))
    - > In excess of 20 feet of the PGE ([Section 25.10, Figure 25-17](#)).
  - Buried to Mobile Home Stake
    - > Within 20 feet of the PGE ([Section 25.10, Figure 25-18](#))
    - > In excess of 20 feet of the PGE ([Section 25.10, Figure 25-19](#)).

Additional rules that must be considered when selecting the placement location for a NID providing service for a mobile home include:

- Ensure all wiring is protected
- If the grounding wire could be disturbed or damaged, it must be:
  - Protected in conduit, or
  - Buried at least:
    - > 12 inches under lawns
    - > 18 inches under driveways
    - > 24 inches where the earth might be disturbed in the future.
- Place any mobile home stake no more than 12 inches from the mobile home
- Placement of a grounding rod:
  - Place where it is not likely to be damaged or disturbed
  - Do not place near a walk, thoroughfare, or anywhere it may become a trip hazard
  - Do not place under a roof overhang
  - Place at least 12 inches from buildings, poles, or trees
  - Place at least 6 feet from any other grounding rod and/or building lightning protection system.

### 25.9.3 Mobile Home and Trailers: Grounding Options

In a mobile home scenario, technicians are required to ground the NID to a primary grounding electrode. While grounding the NID at a mobile home, the preferred methods, in order, are:

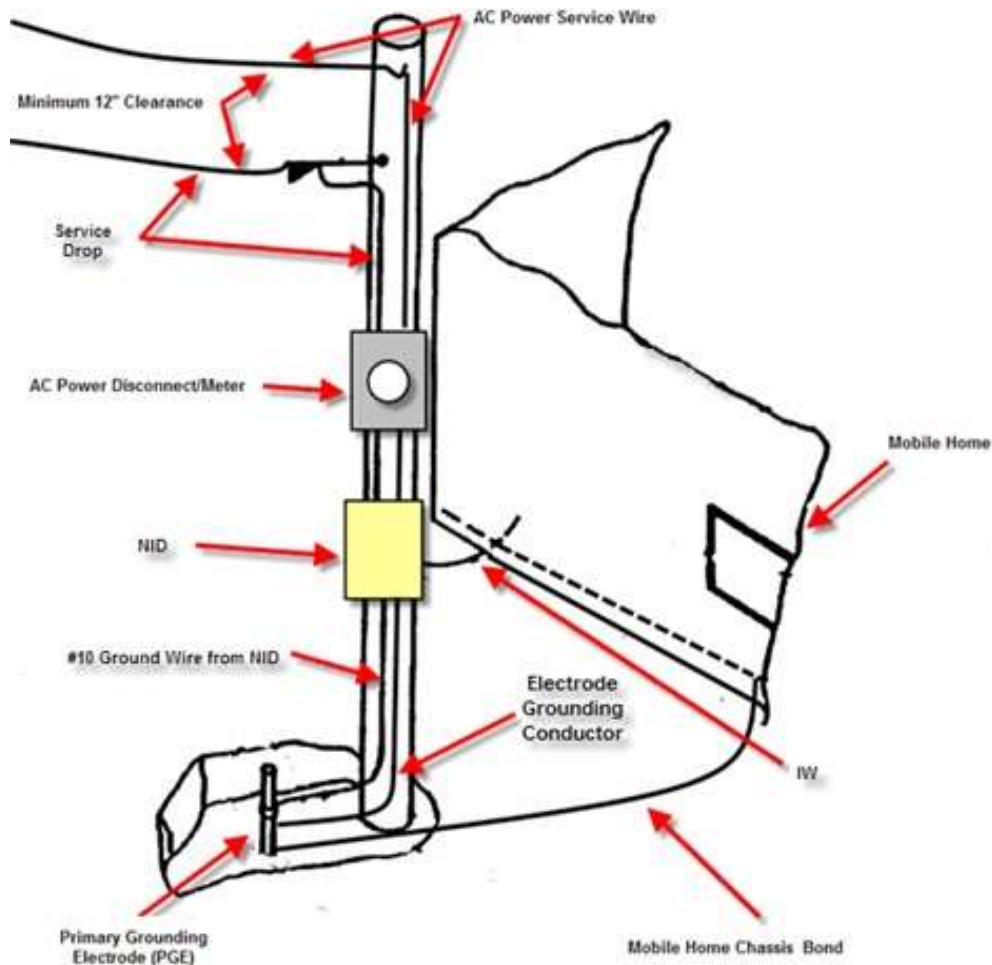
1. Connecting the NID to a primary grounding electrode rod. The telecommunications grounding electrode conductor must not exceed 20 feet in length.
2. Connecting the NID to a grounding electrode conductor. The telecommunications grounding electrode conductor must not exceed 20 feet in length, including the path to the PGE.
3. Connecting the NID to the grounded, rigid metallic power service conduit with threaded fittings leading to the metallic grounded service enclosure/meter box. The telecommunications bonding conductor must not exceed 20 feet in length, including the path to the PGE.
4. Connecting the NID to the customer's metallic grounded power service enclosure/meter using an approved meter box clamp. ***Important: Technicians must ensure that the placement of the clamp does not inhibit access to the meter.*** The telecommunications bonding conductor must not exceed 20 feet in length, including the path to the PGE. If there is a meter box clamp present with the capacity to terminate an additional grounding electrode conductor, technicians must use that existing meter box clamp and not place an additional meter box clamp.
5. Connecting the NID to a 5-foot x 1/2-inch or 8-foot x 5/8-inch telephone grounding rod. The rod must be placed at least 6 feet away from any other grounding rod and/or building lightning protection system. The telephone grounding rod must be bonded to the PGE with a #6 AWG copper wire. Though the bond's length is not restricted, the telecommunications grounding electrode conductor must not exceed 20 feet.

**Note:** To be consistent with grounding practices in other scenarios, limit the length of the grounding electrode conductor to 20 feet, as opposed to the 30-foot limit allowed in the NEC.

If no viable power grounding option exists, technicians may not install services and are required to refer the job to their immediate supervisor.

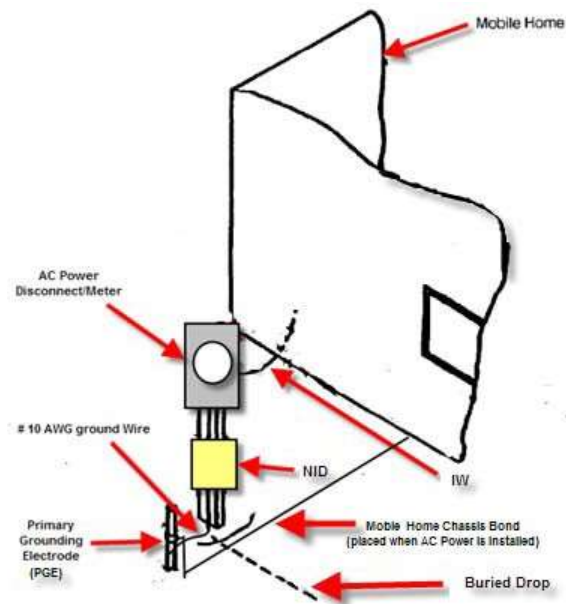
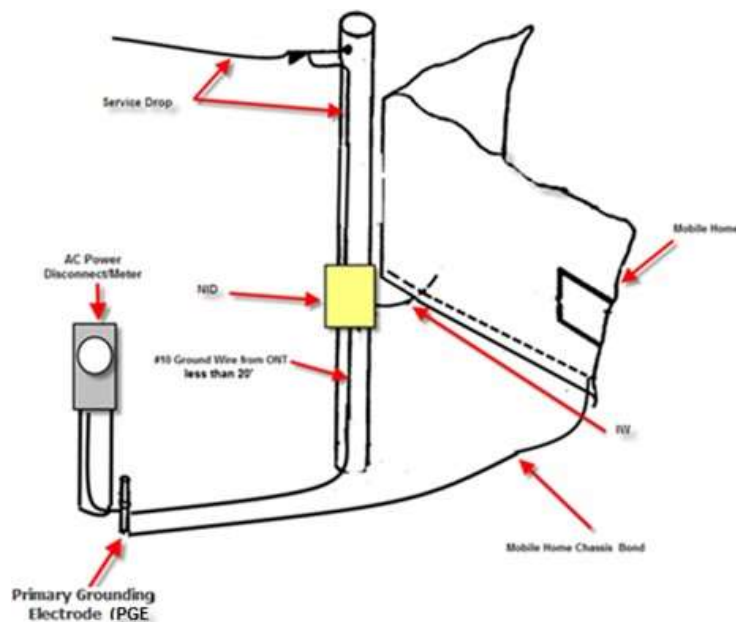
## 25.10 Examples of Grounding Configurations

Figure 25-14 Example 1 - Aerial Service to AC Power Disconnect/Meter



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**Figure 25-15 Example 2 - Buried Service to AC Power Disconnect/Meter****Figure 25-16 Example 3 - Aerial Service within 20 Feet of AC Power Primary Grounding Electrode**

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**Figure 25-17 Example 4 - Aerial Service in Excess of 20 Feet of AC Power Primary Grounding Electrode**

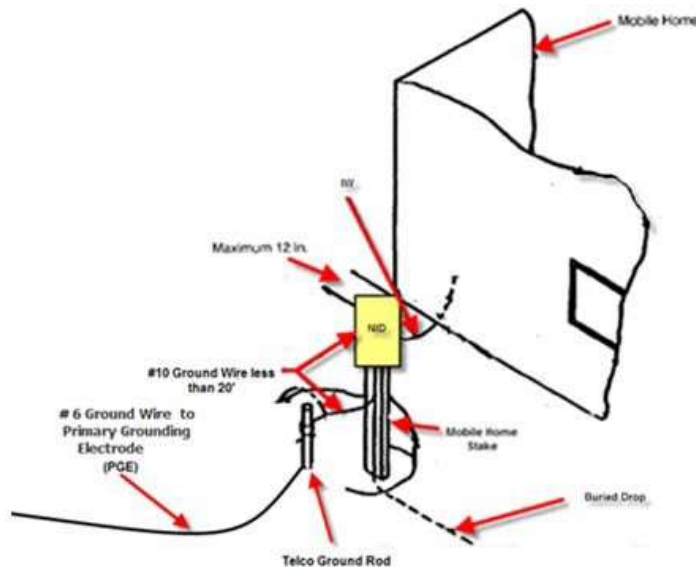
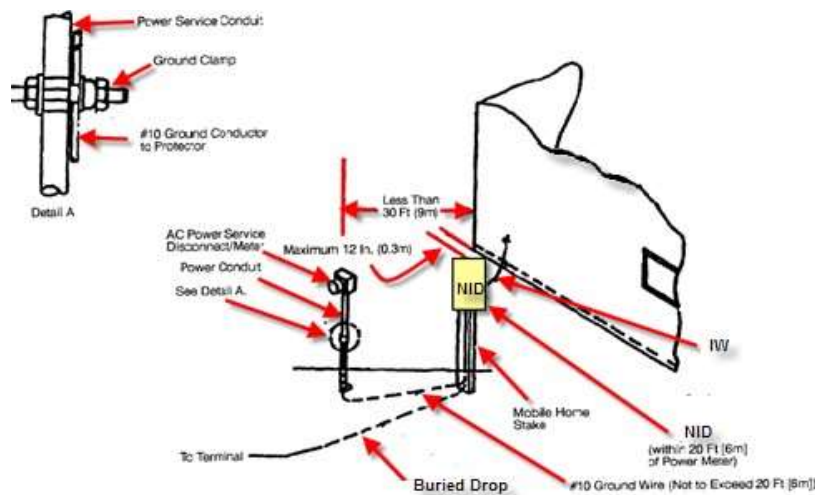


**Figure 25-18 Example 5 - Buried Service to a Mobile Home Stake - Power Service Primary Grounding Electrode within 20 Feet**

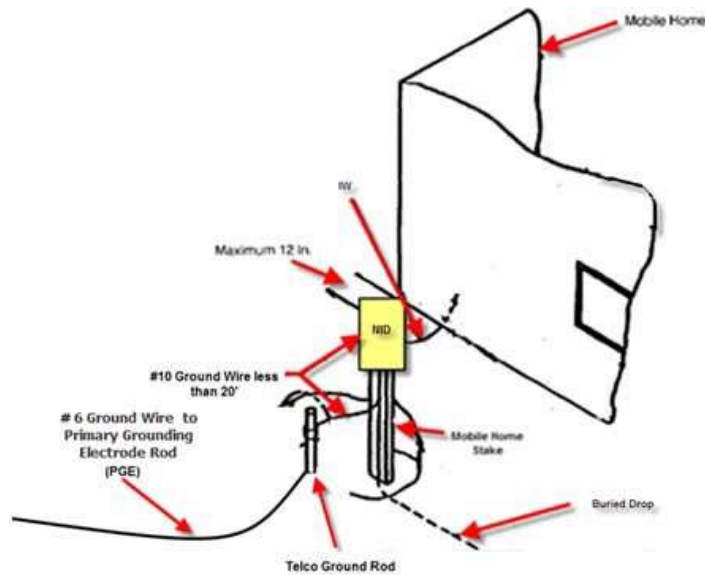


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**Figure 25-19 Example 6 - Buried Service to a Mobile Home Stake - Power Service  
Primary Grounding Electrode in Excess of 20 Feet**



## 26 Joint Use Agreements and California General Orders

### 26.1 Background

Good Joint-use agreements (JUAs) are critical and essential for operational safety and efficiency for telecommunications providers. The service demands for ubiquitous communications at all times and places requires expanded deployment of wireless infrastructure; not only antennas but also the associated back-feed and support equipment for their operations. Because of economics and ready availability, the use of joint-use utility poles will be one, if not the most, likely location for these installations along with other possible sites such as lighting poles (streetlights), buildings, roofs and so forth. All such locations will encounter other utilities either on the same structure or adjacent to them.

To avoid contractual debates, regulatory disputes, licensing arguments, and other legal battles, clear and thorough Joint-Use Agreements will help ensure inter-entity cooperation managing infrastructure that already have electric supply, other communications wireline and wireless facilities, CATV lines, traffic lights and lighting facilities attached on poles or collocated in crowded Right-of-Ways. The term Joint-Use agreement can include not only the formal agreement between the incumbent power and communications (ILEC) utilities (i.e., the usual pole owners), but also regulatory reporting requirements, licensing agreements with other attachers to the structures (e.g., CATV providers, CLEC, traffic control departments of transportation), and pole parity arrangements with other pole owners.

The Federal Communications Commission (FCC) stipulates or mandates specific requirements (FCC 18-133 and FCC 18-111) for fair and nondiscriminatory access by regulated utilities. The obligation of pole owners to provide wireless telecommunications providers access to utility poles at reasonable rates is considered pursuant to Section 224 of the Communications Act. In terms of cost, risk management and operational efficiency, it is far better to have clear, uniform joint use agreements in place than to rely on successful negotiations in regulatory or other legal arenas.

This Construction Blue Book builds off the applicable common safety codes (e.g., NESC, GO95, NEC) and accepted good industry practices to provide technical guidance for such joint use and licensing agreements. Although each geographic area, individual US state, pole owner and company have their own particular operational (economic) needs, reliability concerns, and regulatory requirements, there are common safety and operational considerations for joint use, such as clearances/loading/strength requirements for an attachment request, agreed timelines for approvals, appropriate make-ready cost factors, reporting and inter-company communications that need to be formally agreed upon.

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Each chapter of the Blue Book contains construction guidelines and information that can help in the development, implementation and interpretations of joint use agreements. This new Chapter 26 is devoted to an outline of the components that should be included in a useful and practical Joint Use Agreement (JUA), and a commentary on some of the significant differences between the NESC and GO 95 that may need to be covered in Joint-Use agreements. A useful primer and guide for companies wishing to attach to existing joint-use structures is IEEE Guide P2939 that provides recommendations for the development of consistent guides, agreements, and/or methodologies for the evaluation and inter-company cooperation of managing pole attachments.

Owing to the number of competitors and utilities for space on poles, in underground conduit systems and trenches, across easements and in Rights-of-way, the need for cooperation and clear rules is critical. Guidance and reference documents to the JUA can often include Federal and State regulatory requirements as well as the national safety codes such as NESC and NESC as well as communications industry guidance documents including this *Blue Book*.

Many years ago it became obvious that all parties, including the customer, could profit measurably by sharing poles and trenches, not to mention the environmental benefits. Obviously, no such arrangement can be successful unless a positive and cooperative attitude is shared by all parties. This need for cooperation between all communications and supply utility companies is intrinsic to achieve their safety objectives.

To minimize the proliferation of multiple utility pole lines in communities, electric utilities and communications entities entered into agreements for the joint use of poles and the sharing of pole ownership responsibilities including operating and maintenance procedures and allocations of costs for pole placement, maintenance and removals.

Some of the agreements developed were for shared ownership of individual poles ("Joint Interest") and some were for shared ownership of pole populations in a community ("Pole Parity") with annual accounting to maintain fair burden on each of the participating utilities. All these inter-company agreements can fall under a generic title of "*Joint-Use Agreement*".

With the rise of cable television services in the 1970-80s, the "Pole Attachment Act" [*FCC Pole Attachment Act of 1978 - Title 47 US Code 224*] was enacted and regulations mandating to that attachments to Investor Owned Utility poles or "IOU" (power utilities) and Incumbent Local Exchange Carrier ("ILEC") poles shall be permitted under cost-based just and reasonable rates.

In 1996, the 1934 Telecommunications Act was revised to be replaced by the *Telecommunications Act of 1996* (Public Law 104-104, 110 Stat. 56, February 8, 1996) was revised and permitted Competitive Local Exchange

Carriers (“CLECs”) non-discriminatory access to poles, conduits and right of ways owned or controlled by IOU and ILEC utilities.

Recently the high demand to identify and attach wireless antennas and associated equipment to existing joint-use poles and structures has highlighted the need for JUAs not only for identifying candidate structures for attachments and making the approval process efficient, but also for establishing mutually beneficial RF Safety programs to protect all workers in the vicinity of antennas.

The necessary mutual cooperation between partner companies needs to be codified in Joint-Use Agreements (JUAs), licensing agreements, pole parity agreements and other contractual agreements. Joint-Use Agreements (JUA) are necessary for efficient growth of networks. Clearly written and constructed JUAs help to make construction, installation and maintenance operations more efficient and effective by clarifying the applicable, appropriate, fair (unbiased) and practical processes for attaching to poles, working together on joint use structures, joint excavation of trenches and other construction, installation, maintenance, repair and replacements operations.

Joint-Use and Pole Attachment Agreements are complex and drafting, negotiating and administering them may include many departments of an organization including

- Design and Engineering
- Operations and Maintenance
- Asset Management and Plant Accounting
- EHS (Environmental Health and Safety) and Risk Management
- Finance
- Legal department

All these separate corporate departments of each party to the agreement will be involved in the negotiation, maintenance and enforcement of a pole attachment agreement. The high level guide below may be helpful in crafting an agreement that protects the interests of all parties to the agreement, allows for proper cost savings and recovery, and helps ensure equitable work practices while maintaining the safety and reliability of critical electric and telecommunications facilities.

## 26.2 Features, Format and Elements of Joint-Use Agreements

This section describes the basic elements of JUAs). The details of individual Joint-Use Agreements (JUAs) can vary significantly since the participating entities can often have different priorities, different safety factors and follow

design choices for their networks. However, there are some general common features of JUAs that have proved useful for contractual purposes and operational efficiencies. Below is a JUA outline of these general features and clauses that experience has shown to be useful and beneficial for both parties involved.

### 26.2.1 Front Material – Introduction, Table of Contents, Recital Clauses

The **Introduction**, scope or preamble to the JUA should begin with an introduction or preamble that includes the names, geographic locations and roles of the parties to the agreement as well as the date the agreement is entered into. A typical charging paragraph (scope) for an introduction could read as follows:

*This Pole Attachment License Agreement (the “Agreement”) is made and entered into on the Day/Month/Year, by and between the City of City Name, State, between [Company A] (“Licensor”) and [Company B] (“Licensee”) (collectively, the “Parties”).*

The **Table-of-Contents** is usually complemented by a **Recital** page is a brief description of the contents of the agreement and includes the who, what and why the agreement is being entered into. The summary scope or recital page would include references to the willingness of the parties to enter into the agreement and delineates the services covered under the agreement and lawful requirements. It may include the term of the agreement.

### 26.2.2 Definitions Clauses

The **Definitions** section is essential for any legal contract to help define and clarify terms so that all parties to the agreement understand and use the terms in the same consistent manner. For Joint-Use Agreements (JUAs), some terms of particular and specific interest include –

- Make-Ready (see Section 2.16 for further discussion) - The work necessary to make room for a proposed attachment on a pole. Make-ready may include relocation or rearrangement of an existing attachment, remediation of a preexisting condition, or pole replacement and removal, or strengthening a pole or structure.
- Pole Parity – Whole ownership of a percentage of a population of poles in a community. An annual meeting is usually held by parties to “true-up” the pole ownership ratio after the various pole replacements, new pole installations and pole movements that may have occurred during the past year.

- Property Rights for utility infrastructure can include a large variety of circumstances including -
  - Designated utility Rights-of-Way and land parcels obtained through deeded purchase from or easement agreements with property owners for the right to construct and maintain utility infrastructure,
  - Franchise agreements with government entities (federal, state, municipal) for the right to construct and maintain utility infrastructure on public property or rights-of-way such as roads and streets, and
  - Crossing permits for utility infrastructure to cross pipelines, railroads, rivers, canals or other water ways, and road/highway right-of-way.

In all cases, these authorizations may be permanent in nature or exist only for a stated period of time subject to review and reauthorization. They may require review and approval by the entity granting the property rights, and may incur one-time an/or recurring costs and fees payable by the utility.

- Wireline versus Wireless –
  - Wireline - Wires, cables, conductors and appurtenances that may be used to transmit communications signals over twisted pair copper, coaxial, fiberoptic or other types of wires or conductors.
  - Wireless – Equipment and appurtenances such as antennas, backhaul communications cables and power supplies that may be used to transmit communication signals through the air. Wireless systems may also use wireline equipment for backhauling signals between antenna sites.

### 26.2.3 Scope Clauses

The **Scope of the Agreement** (JUA or Pole Attachment Agreement) should include the following sub-clauses:

- a. Grant of License
- b. Applicability of Standards
- c. Privileges granted under the contract
- d. Limitations on ownership and interest in property
- e. Non-exclusivity - The clause contains language referencing the non-exclusivity of the agreement as well as any limitations on interference with the privileges granted to others on the joint-use structure.
- f. Franchise agreement requirements

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- g. The permitted uses under the agreement
- h. The parties bound by the agreement

A separate clause or sub-clause of the JUA or Pole Attachment Agreement (PAA) will cover the **Private and Regulatory Compliance aspects** including documenting the necessary authorizations, legal/lawful purpose and scope of the agreement, along with a clause for reservation of rights of the parties involved.

#### 26.2.4 Financial Related Clauses – Fees, Charges, Insurance Related

The financial components of any JUA agreement are often the most argued and debated over. These clauses are located in various places within the JUA as costs, fees and charges arise during the operations of the parties and the enforcement of the JUA.

One such clause is the **Fees, Charges and Time Limits Clause** that includes limits on fees/charges for a complete applications and make-ready work. The agreed fees and charges are broken down into recurring charges also known as rental, attachment or license fees as well as the incremental fees for:

- a. **Recurring rental or license fees** may be negotiated but should be consistent with those prescribed by the FCC, the state PUC or local government agencies. The rates, or formula used to derive the fees/rates may be included in the contract or incorporated by reference. The agreement should include language that outlines the conditions and frequency of fee changes.
- b. **Incremental fees** include any costs not related to the utilities net investment in poles and may include items such as the following:
  - (1) **Application Fee** — Can include an administrative charge for the approval request and possibly a fee for access to, and use of, any asset management records for the candidate structure.
  - (2) **Make-Ready Cost Allocations** — A proportional fee(s) for cost causer(s) and make-ready beneficiaries, as well as fair and non-discriminatory recovery of costs. The allocation fee model may treat work in the supply space and in the communications space differently.

As part of the approval process, the pole owner should provide a clear, written estimate of the make-ready costs and timeline of construction. Before construction commences, the pole owner should receive at minimum a written authorization of the proposed make-ready construction. In some cases, the pole owner may require payment before construction.

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- (3) Standard Make-Ready costs — Some pole owners may have fixed fees for simple adjustments; however, most make-ready work is levied at actual costs. Some utilities provide per pole estimates. Early communication and agreements on make-ready costs and timelines are beneficial and critical for construction planning.
  - (4) Application/Review/Survey costs — Pole owners are permitted to recover their costs for reviewing applications. Pricing should be provided in a form agreeable to the parties (fixed fee, per pole, etc.) and should detail invoicing requirements and payment expectations.
- c. The timing and method of payment as well as the acceptable form of payment should be outlined in this section along with specific penalties for non-payment should be clearly defined.

As with any legal and contractual document, an **Insurance Clause** is needed covering the types of insurance coverage and standard liability limits to be included in the agreement. The agreement should stipulate that coverages will be maintained for the entire term of the agreement and the pole or facility owner may need to be listed as additionally insured. The agreement should define the liability and indemnification limits. Surety or performance bonds may be needed to ensure cost recovery by the facility owner in case of default by licensee or gross negligence by the attaching entity. Listed below are types of insurance that may be required in an agreement:

- (1) Commercial General Liability
- (2) Workers Compensation
- (3) Automobile Liability and Property Damage
- (4) Professional Liability – Errors and Omissions
- (5) Excess Umbrella and Specialized Insurance

Evidence of insurance in the form of a Certificate of Insurance should be provided upon execution of an agreement and at on any change in coverage and at the request of the infrastructure owner.

The **Liability and Indemnification Clause** is usual for an any such legal contract and should include verbiage on liability and claims as is determined and required by the parties to the agreement and may include provisions relating to

- a. Assumed fitness and condition of poles – describe the plant care and maintenance program that ensures the pole/plant condition is adequately inspected and maintained on a regular basis and agreed responses for any defects or conditions found by either party to the agreement.

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- b. Agreed contingencies and actions in case of accidental, indirect, special, incidental or consequential damages to define responsibility for physical damage to either party's facilities or loss of service
- d. Covering interference with the operation of Licensee's Facilities
- e. Contingencies for environmental conditions

The corporation attorney or legal department will need to include a contingency clause covering possibility of **Bankruptcy, Receivership, or Foreclosure** with details of process for non-solvency situations that should include:

- a. Notification requirements for bankruptcy, reorganization and receivership
- b. Requirement to remedy any defaults
- c. Requirements for the new owner to comply with the agreement.

A related legal and financial contingency section may be included in a **Performance Bond Clause** where the purpose of such a bond is to ensure performance of the obligations of the parties under the agreement and for the payment of any damages, claims, liens, taxes, liquidated damages, penalties, or fees due to pole owner which arise due to the construction, installation, operation, maintenance, transfer, relocation, or removal of Attachments. The performance bond section could include

- a. Amount and form of the performance bond and other bond requirements associated with exercising the bond option
- b. Process and notification terms for any cancellation of bond

Financial arrangements and contingencies are a necessary part of any legal or contractual agreement and therefore an **Interest on Past Due Clause** sets forth any terms and conditions for past due amounts including the percentage interest charged and related accrual terms.

A legal contract will include sections for **Attorney's Fees** in the case of lawsuit actions arising out of joint-use disputes, compensation cases, or legal actions required to enforce the agreement. Such costs would include *reasonable costs* and attorney fees.

### 26.2.5 Clauses with Operational Consequences

All the clauses noted below have operational and work practice aspects and consequences that will use the guidance and information in the other

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chapters of the Blue Book to meet the requirements of the JUA.

A **Force Majeure Clause** otherwise called the “Acts of God” section whose provisions relieve the parties from performing their contractual obligations if specified circumstances arise that are beyond their control. Such circumstances can include damage to the poles/structures and attachments owing to natural events such as adverse weather and seismic incidents, wildfires and other events not caused by human intervention. In the event of such force majeure events, the parties will often be under additional obligations to

- (1) Mitigate safety hazards that may result from these events
- (2) Establish a priority for repair and restoration activities – e.g., see make safe discussion and working around power guidance in Section 2.1
- (3) Coordinate these activities among the parties.

Some of these actions and obligations were already described in Chapter 2 and other chapters. These M&P obligations can often include maintenance prioritization agreements that can be subject to, in order of importance and task sequence

- (1) Which parties and joint users shall be the first actors to mitigate and/or eliminating any safety hazards to workers and the general public resulting from damage to or destruction of the pole or structure prior to beginning repair and restoration activities
- (2) The pole or structure owner repairing or replacing the pole or structure, and
- (3) Priority and/or coordination of repair/replacement of electric supply and communications attachments to the pole or structure.

As detailed in Chapter 2, the grid power utility worker will most often be the first actor/responder on site to de-energy AC power and make safe the joint use facility for restoration work in the communications space.

The **Duties and Responsibilities Clause** for the parties involved based on knowledge of work area, routine practices and requirements for activity in the worksite on the joint-use structure including items such as:

- a. The duty to inspect the poles prior to attaching and report any condition or defect found (as per NESC Rules 214 and 313).
- b. Provide workers with necessary training and knowledge of the work conditions and work capabilities
- c. The duty to inform and protect all employees, contractors and

- subcontractors working on or around a pole owner facility
- d. Confidentiality and protection of information and source data

One means to require and document the desired operational practices within the JUA is to incorporate standards, codes and material by direct reference. Therefore, the JUA will usually contain a set of nominative **Referenced Standards, Codes or Guides Clause** covering the attachments. These industry best practices and standards for the attachment of wires, cables and equipment to utility poles will often be used as de facto detailed requirements for any attachment or operations. A list of common codes and standards often incorporated in agreements include:

- a. National Electrical Safety Code (NESC)
- b. National Electric Code (NEC)
- c. State of California General Order - GO95 - Rules for Overhead Electric Line Construction
- d. This Telcordia Blue Book - Manual of Construction Procedures
- e. Occupational Health and Safety Administration (OSHA)
- f. Rural Utility Standards (RUS)
- g. State and Local Jurisdictional Codes or Ordinances
- h. Individual Pole Owner and Utility Standards

The referenced ruling documents may also include a **Governing Law Clause** that cites the laws that govern the agreement. These laws are typically the laws that are enforced in the pole owners' State or applicable Federal law.

The **Maintenance, Restoration and Coordination Clause** – The maintenance agreement may be incorporated into a pole attachment agreement or joint-use agreement or be agreed to under a separate agreement. This clause, if present, would include maintenance prioritization agreements to help speed and coordinate restoration after emergency and disaster events that may include the following requirements:

- a. The order of restoration, task sequence and priority of repairs.
- b. Making the worksite safe (make-safe) by identifying the minimum approach distances to wires and cables.
- c. Traffic control barricades and other work requirements to identify and manage any safety hazards to workers and the public resulting from damage to or destruction of the pole, or structure prior to beginning repair and restoration activities.
- d. The coordination of pole repairing or replacing the pole and the

priority and/or coordination of repair/replacement of electric supply and communications attachments to the pole.

- e. The guiding principles for any inspection or audit will often begin with compliance with NESC Inspection Rules 214 and 313 as well as following the other NESC rules along with other referenced documents in the Referenced Standards, Codes or Guide section noted above.

The Audits and Inspections Clause will include the frequency of audits and the appropriate allocation of costs of an audit, along with procedures for any necessary reconciliation of attachment counts and audit result dispute procedure.

Key component of any agreement is to include defined timeframes in a **Term of Agreement Clause** that includes include language to cover schedules and times for:

- a. The initial term and any renewal periods
- b. Remaining obligations following termination
- c. Removal of attachments

with a subtending **Amending the Agreement Clause** to cover the circumstances that may occur from time to time where industry and company standards may be revised to reflect new safety policies, changes in technology and necessary revisions to utility standards. The agreement should make formal allowances and procedures for the:

- a. Right to amend the agreement
- b. Notification of amendments
- c. Remedies for acceptance and/or rejection of amendments.

The **Requests to Attach Clauses** of any agreement should include the rights, responsibilities and a defined process for requesting process and requirements to be followed by any attacher company wishing to place facilities on the joint-use structures. As with all work practices and network plant design/engineering procedures, every pole owner and service provider is guided by their experience to create customized criteria around

- attachments to poles,
- design safety factors used,
- preferred placement and utilization of the vertical space on poles and joint-use buried and underground easements

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As a result, the specifications related to attachments, joint-use situations, inspection programs, and make-ready work can vary widely by pole owner, which creates challenges for infrastructure construction teams attempting to be compliant with the requirements of different pole owners.

With the recent increased demands for more wireless services and optical fiber based broadband networks on joint-use pole infrastructure, the consequences on attachment requests have multiplied around:

- Wireless equipment candidate locations - geographic availability and Rights-of-way issues in different jurisdictions (municipalities, US states etc..
- Appropriate and preferential physical location on pole of communications equipment, antenna and cables
- Pole condition (strength remaining) and general clearances requirements based on NESC (National Electrical Safety Code) and pole owner's safety design factors

Having some of these detailed design and engineering aspects addressed in a JUA is very useful (i.e. more efficient in terms of time to deployment and lower overall cost) to help to provide a safe, reliable communications network, consistent with efficient operations and minimizing maintenance issues.

The administrative permission for adding revisions and updates is usually found under an **Incorporation of Standards, Appendices and Recitals Clause**. To allow for easy amendments and provisions to accommodate new technologies or circumstances, this clause formally permits addition of appendices, exhibits and standards from time to time either by attachment to the agreement or incorporated by reference that become part of the formal agreement. The resolution of disputes or issues that arise can often be incorporated into the agreement in this way.

### 26.2.6 Administrative and Contingency Clauses

The **Failure to Enforce Clause** is designed to cover that failure of either party to take action or enforce compliance does not constitute a waiver or relinquishment of any terms or conditions of the agreement and the agreement remains in effect. An example of this would be; if the pole owner does not perform a post-installation inspection the remaining terms and conditions of the agreement remain in effect.

**Dispute Resolution Clause** is needed to establish a process to resolve any disputes that may happen. Every agreement requires a preferred method for resolution of disputes to help avoid escalation into formal regulatory or legal cases. The clause should include consideration of :

- a. Disputes related to the daily activities of the pole attachment process
- b. Dispute relating to standards
- c. Disputes relating to the agreement
- d. An escalation list for dispute negotiation and resolution
- e. Resolution requirements (FCC, state, and/or local) such as arbitration or mediation if agreement cannot be reached between the parties
- f. Cost allocations for outside resolution

**Administrative Notices Clause** - This clause contains administrative, logistical and technical/operational contact information:

- a. Delivery methods for notices
- b. Contacts for notification – including legal and technical individuals as well as NOC (Network Operations Center) of each party
- c. Emergency contacts and emergency notifications requirements.

A **Termination of Agreement Clause** will include the termination and notification of termination obligations for either (a) **Default** or (b) **Convenience** that should include the following requirements:

- a. Notification requirements in terms of reasons and applicable time frames
- b. Options to postpone or stop the termination action
- c. Disposition of attachments and facilities after termination

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### 26.2.7 Catchall and Miscellaneous Clauses

General catchall provisos will usually be included in an **Entire Agreement or General terms and Conditions Clause** that is included to call attention to the completeness and active validity of the agreement. This section should include:

- a. That the current (latest) agreement supersedes and replaces all previous oral and written agreements with a caveat that
- b. Any previous existing obligations, duties or financial responsibilities of any previous agreement will remain effective and are not waived owing to the execution and acceptance of the new agreement. If there are claims for prior unauthorized use of poles, such claims will usually not be waived because a new agreement has been made.
- c. That the agreement contains all of the provisions, terms and conditions between the parties for the purpose of the agreement
- d. Such a general section may also contain a **Severability Clause** that seeks to make sure that if any specific part of the agreement such as certain clauses, sentences or sections is declared invalid the remaining sections of the agreement remain in effect.

Often a party to the agreement may include a **Miscellaneous Provisions Clause** that has developed out of their experience with other companies or circumstances in particular municipalities, states or geographic areas. Such a clause may include provisions that were not directly referenced or implied in the initial draft of the agreement such as :

- a. That the new attaching entity to a joint-use structure is not responsible to get a new permit or attachment license for any properly licensed and authorized pre-existing attachment.
- b. Contractor working for the attaching entity are bound by the terms of the agreement. OSHA considers that the company hiring contractors is responsible to ensure that these contractors follow the appropriate OSHA rule and follow industry best work practices
- c. That the agreement is reciprocal if attaching entity owns poles and utility pole owner desires to attach to their poles
- d. Only the parties to the agreement enjoy the benefits of the agreement.

A final page of this and every contract/agreement will have a **Signature Block Clause** for the corporate officer signing for the company and acknowledging the obligations, rights, and responsibilities apply across all the members of their company.



## 26.3 JUA Roles in a Wireless Attachment Approval

As an example one can consider the wireless attachment approval procedures and how the role of the JUA can assist the process.

**Wireless Attachment Process** - For wireless attachment purposes, the JUA, pole attachment agreements and/or licensing agreement need to include a well-defined process for any attachment requests, along with approval/denial protocols, reasonable timelines for moving forward with attachments.

The defined guidelines for the pole attachment process must be consistent with associated regulations, such as the NESC and FCC, would be included as a separate clause or as a supplement to the attachment agreements.

Listed below are a few examples of items that may be included possibly in a flow chart format including timelines that specify minimum return times for application steps after initial application submission is made and JUA signed between parties signed.

- Initial administrative check which reviews that all necessary information requested is present in application. The preferred method of submitting surveys and applications is electronic. Providing applications in an electronic format allows for improved tracking and reporting capabilities. With the importance of timelines and the inherent challenge of communication between an applicant and the pole owner, utilizing a system that allows both parties to monitor the status of a proposal is invaluable.
- Preliminary technical review to help ensure minimum clearances, loading calculations, product specifications, and other provided data is compliant with NESC or other specified safety and design criteria for the new attachment or other joint-use installation being requested; i.e., overlashing a cable to existing strand or adding strand-mounted equipment. Without defined criteria listed in the JUA or incorporated by reference then the provisions of the One Touch Make Ready (OTMR) procedures from the FCC will be applied. Items that may be useful include:
  - A map showing each of the poles for which the attacher is applying should be provided along with pole identification number, pole type & usage,
  - Identify the owner(s) of the land or Rights-of-way (easements) for the pole.



- If new underground or direct buried cables are required for powering or backhaul communications for the candidate wireless equipment, a route map for the supporting cables should be provided with planned burial depth and cable/conduit specifications. Such route maps should include all known existing underground or direct-buried utility facilities.
- Field Surveys and Review – entailing a physical visit to site for verification of on-site information and to determine any what type and level of make-ready work required.
  - These field surveys may include the preliminary use of satellite/drone imagery, site photographs, data capture technology for digital storage and transmission of data allowing for easier coordination of multiple sites and more reliable transmission and improved quality control for larger applications.
  - Having a designated delivery route and tracking system for information and the approval process is key as it is anticipated that many small wireless installation projects will be attempting to access multiple poles in a shorter amount of time.
  - All surveys physically written on paper should be scanned electronically and included with the loading studies to provide adequate reference for attachment heights and facility identification at each site.

The engineering survey and technical evaluation of the attachment request for a pole attachment shall include:

- Name of pole owner and any specific location information (GPS – Latitude, Longitude or street address, pole tag identification information)
- Required grade of construction (based on NESC), span lengths, configuration (tangent, line angle or “pull”, etc.)
- Pole type—wood, steel, concrete, fiber-reinforced composite, and so forth with detailed information such as pole class, length, height above ground, and depth of set (if available)
- Pole state and condition: describe significant decay or damage that would significantly reduce the strength and/or compromise the ability to safely work on the pole

- Number and nature of current attachments, with the attachment owner identified where possible—including sizes (diameter, dimensions), and type (wire/cable/strand, terminal, transformer, streetlight, pothead, guy, riser, crossarm, etc.)
- Height of existing communications lines, and the lowest power facilities – information required to maintain or establish the Communication Worker Safety Zone (CWSZ) after attachment of proposed wireless facilities
- Special considerations such as (1) special situations (e.g., railroad, interstate highway, etc.) that may require large clearances or higher grades of construction, (2) pole locations where the communication route will need to go underground and require a riser, or (3) mitigating factors associated with location on private/public land or ROW/easement restrictions
- Any other information that assists in identifying the pole and is relevant to pole loading (transformers, number of primary phases, etc.)
- Pictures of the pole(s) and surroundings are beneficial to help clarify approval/denial decisions and to document the condition of the pole at a specific point in time. Current scanners, digital photography tools come equipped with software that purports to measure clearances, separations and even estimate appropriate sags/tensions for lines attached to the pole under considerations.
- Any existing condition or defect affecting compliance with the NESC such as broken or missing hardware, evidence of collision damage, and insect or bird damage. As per NESC Rules 214A4 and A5, any such condition or defect should be reported to the pole owner for correction or appropriate action.

Additional optional information may also be gathered and documents during the field visit that although not strictly required for a pole owner to approve the attachment request, the information will avoid delays and added costs during the make-ready and initial construction work. For example, the accessibility of pole and existing attachments (e.g., need for a bucket truck, ladder, climbing space, etc.) as well as nearby utility structures (underground or aerial), railroads, roadways or other mitigating factors that may interfere with construction of, or operation, new communications facilities.

As a part of best practice, the pole owner should perform an inspection after receiving notification of the completed attachment. The purpose of the inspection is to ensure proper clearances have been met and that the

construction was completed within the established guidelines of the pole owner. The JUA should dictate the timelines of the inspections or at least minimum intervals and or response times as well as who is responsible for the cost of the inspection.

At the end of the evaluation process and to avoid confusion and legal disputes, the pole owner should provide that specific technical reasons with any denied application for a wireless application. Although the JUA is not the document to list every possible reason, common problems that may cause delay are incomplete data or missing information specifically requested by the pole owner(s) (e.g., clearances, pole loading, location, or prior equipment approval), or any incompatibility with requirements defined in the JUA through reference to standards such as NESC or this *Construction Blue Book*.

There may also be reliability or safety concerns regarding other workers or the general public such as:

- Installations likely to degrade the network reliability or service quality of the systems on the structure.
- Inadequate attachment hardware or mechanical engineering issues which can result in hardware and/or pole failure at the connection point of the structure or at any point in the assembly.
- Potential conflicts with passing truck/vehicle traffic or pedestrian activity arising from insufficient clearance as per NESC Rule 232.
- Applications may be denied because of aesthetics, although such decisions must be as objective and uniformly applied to all parties. Some generally accepted reasons for denial based on aesthetics include:
  - Excessive wiring with no attempt at cable management/organization
  - Equipment appearance does not align with requirements defined by the local jurisdictions and communities.

The general principles to be used for evaluating an attachment request can be included in the JUA as a clause or as an attachment to help establish uniform procedures and an unbiased relationship with all potential attaching companies.

## 26.4 California General Order 95 and 128

In California and some western States of the USA, the General Orders (GOs) are used instead of the NESC. Table 26-1 below shows some of the GOs that apply to communications companies and to the joint-use structures that communications share with power utilities. The key General Orders for the issues covered in this Blue Book Guide for communications are highlighted below in yellow and include GO 95 (Aerial Plant) and GO 128 (Buried/Underground Plant) that are coupled with California OSHA regulations for applicable work rules (i.e., corresponding to Part 4 – Work Rules – of the NESC).

**Table 26-1 Selected California General Orders**

| <b>General Order</b> | <b>Description</b>                                                                                                                        |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 52                   | Construction and operation of power and communication lines for the prevention or mitigation of inductive interference                    |
| <b>95</b>            | <b>Overhead electric line construction.</b>                                                                                               |
| 104                  | Filing of annual reports by public utilities                                                                                              |
| 107                  | Privacy of telephone communications                                                                                                       |
| <b>128</b>           | <b>Construction of underground electric supply and communication systems.</b>                                                             |
| 133                  | Rules Governing Telecommunications Services (Service Quality)                                                                             |
| 165                  | Inspection cycles for electric distribution facilities.                                                                                   |
| 167                  | Enforcement of Maintenance and Operation Standards for Electric Generating Facilities.                                                    |
| 168                  | Consumer Bill of Rights Governing Telecommunications Services. Market Rules to Empower Telecommunications Consumers and to Prevent Fraud. |
| 169                  | Implementing the Digital Infrastructure and Video Competition Act of 2006 (DIVCA)                                                         |
| 171                  | Rules Governing Filings Made Pursuant to the Telecommunications Act of 1996                                                               |
| 174                  | Rules for Electric Utility Substations                                                                                                    |

Below are several tables with the GO 95 minimum clearances and summary figures of the applicable values for communications cables. The small

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differences in most of these minimum clearances between NESC and GO 95 are based in the conditions under which the measurements are calculated or made along with the exceptions and allowances that apply for specific applications, environments and conditions in each code. The NESC has a set of worst conditions under which the minimum sag values apply (see Chapter 3).

**Table 26-2 GO 95 Vertical clearances for cables above ground**

|          | Where/What wires or cable cross over                                                                                                                                                                 | Distribution/Drop<br>Spans along pole<br>line | Communications<br>service drops |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------|
| <b>1</b> | Highways, streets, roads or alley in urban or rural areas                                                                                                                                            | 18 feet                                       | 18 feet                         |
| <b>2</b> | Railways - Crossings above tracks which transport freight cars with minimum height of 15ft-6in feet. Some railroads require 29 feet minimum to accommodate allowances for ice and wind loading sags. | 25 feet                                       | 25 feet                         |
|          | Overhead lines for trolleys                                                                                                                                                                          | 26 feet                                       |                                 |
| <b>3</b> | Driveways in urban or rural areas                                                                                                                                                                    |                                               |                                 |
|          | (A) Commercial or agriculture premises                                                                                                                                                               | 18 feet                                       | 16 feet                         |
|          | (B) Residential Premises                                                                                                                                                                             | 18 feet                                       | 12 feet                         |
| <b>4</b> | Private vehicular entrance to fields, orchards, etc. in rural districts.<br>Some newer tall harvesters can create conflicts with low lines pass.                                                     | 15 feet                                       | 15 feet                         |
| <b>5</b> | Areas not under cultivation and over which there is no likelihood of vehicular traffic agriculture traffic                                                                                           | 13 feet                                       | 13 feet                         |
| <b>6</b> | Areas accessible to pedestrians only                                                                                                                                                                 |                                               |                                 |
|          | (A) Industrial and commercial only                                                                                                                                                                   | 10 feet                                       | 12 feet                         |
|          | (B) All other areas                                                                                                                                                                                  | 10 feet                                       | 10 feet                         |
| <b>7</b> | Roofs of all buildings on premises served                                                                                                                                                            |                                               |                                 |
|          | (A) Roofs having pitch less than 3/8                                                                                                                                                                 | 8 feet                                        | 3 inches                        |
|          | (B) Roofs having pitch 3/8 or greater                                                                                                                                                                | 2 feet                                        | 3 inches                        |
|          | (C ) If conductors do not overhang building by more than 6 feet                                                                                                                                      | 2 feet                                        | 3 inches                        |

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|   | Where/What wires or cable cross over                                                                                                                                   | Distribution/Drop<br>Spans along pole<br>line | Communications<br>service drops |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------|
| 8 | Roofs of buildings other than premises served                                                                                                                          |                                               | 8 feet                          |
|   | (A) Roofs having pitch less than 3/8                                                                                                                                   | 8 feet                                        | 2 feet                          |
|   | (B) Roofs having pitch 3/8 or greater                                                                                                                                  | 2 feet                                        | 2 feet                          |
|   | (C ) Where conductors do not overhang building by more than 6 feet roofs of any pitch                                                                                  | 2 feet                                        |                                 |
| 9 | Where wires or cables run along highways, streets or alleys                                                                                                            |                                               |                                 |
|   | (A) In urban districts generally                                                                                                                                       | 18 feet                                       |                                 |
|   | (B) in Rural districts generally                                                                                                                                       | 15 feet                                       |                                 |
|   | (C ) In rural districts only where no part of the line overhangs the thoroughfare originally traveled and where it is unlikely that vehicles will cross under the line | 13 feet                                       |                                 |
|   | (D) Where the ground underneath is accessible to pedestrians only                                                                                                      | 10 feet                                       |                                 |

**Table 26-3 GO 95 Vertical and Horizontal Clearances for Communications Cables**

|    | Plant Condition and/or Activity<br>under Lines                                            | Minimum<br>Clearances | Comments                                                                                                                                                         |
|----|-------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10 | Horizontal clearance of line (at rest) from buildings                                     | 3 feet                | Exception for generating plants and substations.                                                                                                                 |
| 11 | Radial center line clearance of unattached plant that is not part of overhead line system | 1 foot                | These radial centerline clearances are from cable to non-climbable street lights, traffic signal poles, mast arms, and antennas not part of overhead line system |
| 12 | Water Areas not suitable for sail boating                                                 | 15 feet               |                                                                                                                                                                  |
| 13 | Water Areas suitable for sail boating                                                     | 18 feet               | Where area is less than 20 acres                                                                                                                                 |
|    |                                                                                           | 26 feet               | Where area is more than 20 acres but less than 200 acres                                                                                                         |
|    |                                                                                           | 32 feet               | Where area is more than 200 acres but less than 2,000 acres                                                                                                      |
|    |                                                                                           | 38 feet               | Where area is more 2,000 acres                                                                                                                                   |

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**Table 26-4 GO 95 Vertical Clearances for communications cables not supported on the same pole**

|    | Clearance from                                                      | Minimum Clearances | Comments                                                                                                         |
|----|---------------------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------|
| 14 | Span wires – guys and messengers                                    | 2 feet             | Distances are measured vertically at crossings in spans and radially if co-linear or as approaching crossings. . |
| 15 | Trolley contact conductors (0-750 Volts)                            | 4 feet             |                                                                                                                  |
| 16 | Supply conductors, service drops, and trolley feeders (0-750 volts) | 4 feet             |                                                                                                                  |
| 17 | Supply conductors 750-to-7,500 volts                                | 4 feet             |                                                                                                                  |
| 18 | Supply conductors 7,500-to-20,000 volts                             | 6 feet             |                                                                                                                  |
| 19 | Supply conductors greater than 20,000 volts                         | 8 feet             |                                                                                                                  |

**Note:** In general, light rail and trolley line are treated as power lines.

**Table 26-5 GO 95 Clearances for communications cables from signs**

|    | Clearance of lines from signs on buildings and isolated (stand-alone) structures | Minimum Clearances |
|----|----------------------------------------------------------------------------------|--------------------|
| 20 | Vertical clearance above signs where persons can walk                            | 8 feet             |
| 21 | Vertical clearance above signs where persons cannot walk                         | 2 feet             |
| 22 | Vertical clearance under signs which are illuminated                             | 2 feet             |
| 23 | Vertical clearance under signs which are not illuminated                         | 6 inches           |
| 24 | Horizontal clearance under signs which are illuminated                           | 3 feet             |
| 25 | Horizontal clearance under signs which are not illuminated                       | 6 inches           |

**Note:** In general, light rail and trolley line are treated as power lines.

**Table 26-6 GO 95 Other Horizontal Clearances**

|    | Horizontal Clearances from      | Minimum Clearances | Comments                                   |
|----|---------------------------------|--------------------|--------------------------------------------|
| 26 | Between Poles and Fire hydrants | 4 feet             |                                            |
| 27 | Between Poles and Curbs         | 6 inches           | from surface of pole to field side of curb |
| 28 | Between poles and Railroads     | 12 feet            | measured to the nearest rail               |

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Below are several GO 128 clearance and depth requirements applicable to buried and underground systems

**Table 26-7 GO 128 Clearances**

|           | Nature of Clearance or Depth                                                        | Minimum Requirements                                                                             | Reference GO 128 Rules                      |
|-----------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------|
| <b>29</b> | Clearances between supply and communications cables if independently installed      | 3 inches of Concrete,<br>4 inches of Brick, or<br>12 inches of Earth                             | 33.4A(1) (a)<br>33.4A (2) (a)<br>43.3A      |
| <b>30</b> | Cables if concurrently installed                                                    | No separation required if parties mutually agree. [random separation rules in Rule 43.3B(1)]     | 33.4A(1) (b),<br>33.4A (2) (b),<br>43.3B    |
| <b>31</b> | Cable and ducts from foreign structures                                             | 12 inches when paralleling and<br>6 inches when crossing                                         | 31.4A(1),<br>33.4A(3)(a)<br>41.4A(1), 43.3A |
| <b>32</b> | Separation of Communications cables and Supply duct systems independently installed | 3 inches of Concrete<br>4 inches of Brick, or<br>12 inches of Earth                              | 31.4B(1),<br>41.4B(1)                       |
| <b>33</b> | Separation of Communications cables and Supply duct systems concurrently installed  | No separation required when parties mutually agree and both systems are in rigid ducts           | 31.4B(2),<br>41.4B(2)                       |
| <b>34</b> | Depth<br>Depth of cables and ducts under railroad beds                              | 30 inches Below street railroads,<br>42 inches Below other railroad                              | 31.4C(1),<br>33.4B,41.4C(1),<br>43.3        |
| <b>35</b> | Depths of Supply cables and ducts                                                   |                                                                                                  | 31.4C,<br><br>33.4C,<br>33.4D               |
|           | (A) 0-750 Volts:                                                                    | 24 inches below thoroughfares.<br>18" elsewhere (under sidewalks, parkways and private property) |                                             |
|           | (B) 751-35,000 Volts                                                                | 24 inches                                                                                        |                                             |
|           | (C) Above 35,000 volts:36                                                           | 36 inches                                                                                        |                                             |
| <b>36</b> | Size and shape of manholes                                                          | Minimum inside dimension shall be 4-feet by 5-feet high.                                         | 32.4,<br>42.4                               |
| <b>37</b> | Manhole openings                                                                    | Not less than 26 inches in diameter or 26-inches x 24-inches rectangular                         | 32.5,<br>42.5                               |
| <b>38</b> | Manhole location                                                                    | Manhole openings shall not be less than 3-feet from any railroad rail                            | 32.8,<br>42.8                               |

For reference, below are commentaries and explanations for several specific sections of GO 95 and GO 128 that were developed for a build-out project in San Jose and around the Bay area in California. Although these observations were

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for a specific project, they contain general guidance for areas where GO 95 and GO 128 apply.

The General Orders and the NESC are both safety codes and have the same objectives of safety for workers and the public. Following the construction and installation guidance provided in the other chapters of this Blue Book shall in general bring compliance with much of the GOs. However, users in the areas where the GO 95 and GO 128 apply will need to check the precise clearance, separation and strength/loading values with the latest issue of those General Orders.

### 26.4.1 GO 95 Rule Considerations and Commentary on Practices

**Vertical Cable Runs** (as per GO 95 Rule 84.4) - Vertical runs of communication wires or cables supported on the surface of wood poles or structures, shall be covered by a suitable protective covering (see Rule 22.8) where within a vertical distance of 3 feet above or 6 feet below unprotected supply conductors supported on the same pole or structure. feet above or 6 feet below the level of unprotected supply conductors need not be covered.

**Climbing Space** (as per GO 95 Rules 20.7/34/84.4D/93) means the space reserved along the surface of a climbable pole or structure to permit ready access for linemen to equipment and conductors located on the pole or structure. Climbing space shall be maintained from the ground level. The attaching (licensee) company should strongly endeavor to maintain one side or one quadrant of the pole clear from ground line to pole top with either plastic covering or wood molding used to protect the vertical run.

**Bonding** (as per GO 95 Rules 83.4, 20.6, 22.8) The bonding of communications messengers strands together helps to remove step and touch potentials between messengers and lines. Bonding of cable shields/armors across closures and splices is used to help maintain electrical continuity of metallic conductor components across the network. Bonding helps protect workers against electrical shock and equipment (facilities) from degradation caused by foreign voltages and induced currents.

1. Use a minimum 6 AWG sized conductor for bonding conductors
2. Use listed connection devices to ensure attachments and connections are secure and reliable
3. Complete bonding at regular intervals which can occur most conveniently at the same pole where the grounding connection is made. Per GO95, this should be more frequently than 4 times per mile (less than 1320 ft). Typical rules of thumb for grounding intervals that have proved useful in the past include every 1000 feet or every 10th pole along a pole line.

**Grounding** (also see Bonding) – as per GO 95 Rules 83, 84, 86, 87, 88, 92.4, 94.3, and 22.8 - The term bonding and grounding are often used interchangeably but are not the same and do not produce the same end results. Grounding eliminates potential differences between the plant element and earth and creates a low resistance, low impedance path to ground (earth). Bonding and

grounding are effectual only when the plant elements involved are conductive. Grounding combines with bonding of various communications messengers to help create an effectively grounded system and eliminates potential differences between two or more plant elements to help prevent the risk of shock through step-and-touch potentials, as well as help drain off induced voltages that may be on the strand. Bonding and grounding of messenger strands and metallic conductive elements of the fiber cable shall:

1. Use at least a 6AWG sized conductor for bonding and grounding conductors
2. Use listed or approved bonding and grounding connection and clamping devices to ensure attachments and connections are secure and reliable (
3. The connections shall be properly sized to accept strand and form a low resistance reliable connection.
4. Complete grounding at regular intervals which as per GO95, this should be more frequently than 4 times per mile (less than 1320 ft). The typical grounding intervals that have used for guidance include every 1000 feet or every 10th pole along a pole line.
5. Use a 5/8 inch x 8 foot long ground rod located at least 24 inches from pole surface, if practical.
6. Messenger strand shall be bonded to existing communication grounds and to adjacent messengers of other communications companies with approval. Vertical grounds from the power supply space shall NOT be bonded to unless specific permission and approval is obtained from the power supply company.

Bond and ground at all poles that have an existing vertical communications ground. If no vertical ground exists over substantial distances, the fiber/strand installation shall be effectively grounded every 1,320 feet.

**Clearances** - Factors that need to be considered in determining the adequate clearance between conductors, equipment and all the different items attached to the pole include the following:

- Electrical hazard levels for workers in the vicinity of supply equipment
- DC- or AC-voltage levels
- Operating voltage and power levels of the equipment
- Altitude (above sea level) of facility
- Grounding and bonding of equipment and closures.
- Physical size and position on pole
  - Sufficient climbing space for all joint users of the pole
  - Sufficient working space on pole for installation and maintenance activities.

Accurate identification of electrical hazard is dependent on equipment type, design, function and interconnection with the supply grid conductors.

**Vertical Clearances above ground**– (as per GO 95 Rules 37, 38 – Tables 1 and 2, 84, 20 , and 31) - Increased clearances and separations are required around

and above highways, railroads and other surfaces depending on expected activity in the area. A reference baseline of 18 feet clearance across roadways is a minimum value with design objectives aiming at 20-22 feet at least to allow for weather changes during the year, possible wind and ice loading, roadway resurfacing, and other variations over the lifetime of the plant.

**Clearances or Separations between lines** - (as per GO 95 Rules 84, 37/38 (Tables 1 and 2) – The baseline minimum separation between power and communications lines/equipment of **48 inches** (where guarded) and **60 inches** (where unguarded) is defined to help maintain safety of the public and workers on the pole. One objective of these safety clearances is to provide sufficient access, climbing space and working space around this plant for the safety of communications and supply workers on the pole; with commensurate protection for the facilities and equipment.

- 12 inches minimum separation between communications conductors supported on the same pole/structure.
- 48 inches minimum separation between communications conductors and power lines supported on the same pole/structure.
  - 48 inches if guarded (crossarm)
  - 72 inches if exposed (no protective cross arm)

For the larger closures planned for deployment in the fiber build-out, it may be a challenge to keep separation from a communications line attached to the same or adjacent pole. The objective should be to avoid contact to help avoid abrasion or mechanical stress to either facility.

**Guying** - (as per GO 95 Rules 86 and 35, 56 with safety factors consistent with Rule 44) – Guys are required and used to balance the lateral forces that may be placed on poles with particular attention to directional changes in pole lines (at bends and corners), poles at crossing points, and dead end poles. All required guying must be in place before placing and tensioning the supporting strand.

The sizing of guys and strands needs to be customized for specific geography and soil types. For example, for a project in San Jose (Bay area of California) the general recommendations for guys (See Chapter 4, 6 and 8) were -

- For guying at angles or dead ends, it is recommended that a “Lead over Height” of 1 be used.
- For applications where a small strand is sufficient, use either 6 or 6.6 M strand (recommended to pick one size only)
- In general, use 10 M strand for down/sided guys. One can use two 6M strands for guys instead.
- Use Helical anchor (twin helix) and rod with rated size of 10M or 12 M size for most applications with some rock anchors available if necessary.

**Isolation** – (as per GO 95 Rule 20.4) - This defined term means the conductive members of a non-dielectric fiber optic cable facility have been conditioned to prevent the transfer of system voltages from one level on a structure to another. This is achieved primarily through the physical separation and clearances between the lines, messenger strands and equipment on the pole and

underground (see Clearance); coupled with separate grounding systems (see Bonding and Grounding).

**Isolation of Guys** - In general, all exposed guys should be insulated or grounded; unless they have guy isolators installed (e.g., in overhead and anchor guys) so as to help limit the likelihood of any portion of the guy becoming energized within 8 feet of the ground in the event of that the span guy becoming slack.

**Testing and Inspections** – (as per Rules 12.2, 17, 31.2, 35, 80.1, 20.4) - Within the GO 95, testing and inspection programs are required for utilities by various rules. The initial construction audits performed during this build-out will be used as the documented baseline for any future inspection or testing. Employees shall be trained to include inspection & testing protocols for the facility before routine work on the pole; as well as consideration of adjacent and nearby facilities for any conditions or defects that need attention. Furthermore, systematic inspection programs are used by many companies to meet the objectives of the regulations and help identify possible problems and proactively fix prior to any loss of, or degradation, of service. Documentation of the inspections, and any found conditions/defects needing action is critical to help meet regulatory and legal requirements.

**GO 95 is not retroactive & not a design manual** - (as per GO 95 Rules 12.3, 13, 14, 31) - GO95 does not require wholesale rebuilds to latest code. However, if the addition of a licensee cable changes the structure sufficiently then GO 95 would require meeting the latest GO 95 rules. The minimum/maximum clearances and separations specified in GO 95 should be exceeded when practical. If a condition on construction configuration is not strictly covered in GO 95 then best industry practice should be used so as to help ensure that the *“operations of other utilities and the convenience of the public will be interfered with as little as possible and no conditions unusually dangerous to workmen, pedestrians or others shall be established at any time”* as far as practical and possible.

**Cooperation and Approval Assumption** - (as per GO 95 Rules 31.4, 31.5, 32.2, 34, 44, Section IX, ) - GO95 rules in general are based on strong assumptions around cooperation existing between all parties on the joint use plant – power, incumbent communications and licensee utilities and companies – and the obtaining of approval and agreements from all joint users on the pole. The current state of cooperation between power utilities and communications companies and between different communications companies in California remains a challenge.

**Construction Grades and Safety Factors** - - (as per GO 95 Rules 40-49, 81, ) – Communications circuits are usually Class C with Class B being required for some joint uses with high voltage lines or over railroad crossings as classified and defined in Rule 41-42 and in Table 3 of GO 95. In general, design safety factors of 2 are usually applicable to the engineering and design considerations for communications lines and pole attachments. For 3rd party licensee attachers, Rule 44.2 and 44.3 specifies that a design calculation needs to be done and includes consideration of the state/condition of the pole. Also an attacher needs to consider not only the replacement safety criteria set by GO 95 Rule 44.3 but also the internal performance criteria established by the pole owner and other joint users (supply and communications companies) sharing the pole.

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## 26.4.2 GO 128 Considerations and Commentary on Practices

(See Table 26-7 above)

**Maintaining Clearances and Depths** - GO128 – Rule 41.4.D – The buried and underground GO 128 contains several general requirements with the following three items of key importance for a new installation in the utility rights-of-way:

- 1) Any person or agency performing surface or subsurface construction in the vicinity of communication duct systems is enjoined to maintain the minimum clearances from, and the depths of, existing systems as required by these rules.
- 2) If minimum clearances and depths cannot be maintained, then the person or agency causing changes is enjoined to notify the owner of the duct system.
- 3) Under the provisions of this rule a previously installed system may be maintained with less than the top cover required by other applicable rules of this section provided the duct material itself or additional top protection installed has sufficient strength to protect the system from injury by traffic.

**Horizontal Clearances** – To meet the GO 128 separations noted in Table 26-7 installation designs will often use the following as a general design objectives for horizontal clearances:

- 1) Minimum of two (2) feet horizontal clearance from proposed new conduit to other existing utilities (excluding gas and water mains)
- 2) Gas Mains – maintain a minimum two and a half (2.5) feet horizontal clearance from proposed new conduit to existing gas mains
- 3) Water Mains – maintain a minimum three (3) feet horizontal clearance from the proposed new conduit to existing water mains

If the installation is within one (1) foot horizontal clearance from proposed new conduit to other existing utilities (excluding gas and water mains), then the excavation should proceed with hand digging procedures. Often (in urban parts of California) the above horizontal clearances are mandated by the municipalities. More strict requirements applied by local cities can often be found in California.

**Buried Plant – Depths** - The buried plant should be installed so that the minimum depth of cover as shown in Table 26-7 will be obtained. In some cases, however, additional cover is necessitated by other factors concerning the expected activities on the area. Such conditions include, but are not limited to, the following:

**Croplands and Pastures** - A cable depth of 36 inches is minimum. Where subsoil plowing is done, the cable should be located at least 12 inches below the maximum depth attained by such agricultural equipment.

**If crossing railroads, highways, and streets** - The depth of the plant should be sufficient to minimize the possibility of mechanical damage due to road

grading or ditching activities and the usual maintenance work along the highway or railroad right-of-way.

If making a railroad crossing - The facility shall be at least 60 inches below the top of the rails.

If working on rough or unfinished grade levels: The trench depth should be sufficient to meet minimum depth requirements at final grade level.

Directionally Bored Facilities – Shall maintain a depth of 36-to-48 inch clearance to under cement pads (e.g., traffic islands).

Roads and Curbs – Buried utilities shall be located 3 feet back from face of curb in general. In downtown/urban areas, manholes and vaults in the sidewalk will be located four (4) feet from the back of curb.

Although these observations and commentary above were developed were for a specific project in one municipality region, they have general applicability across California. The General Orders (GO 95 and GO 128) and the NESC are both safety codes and have the same objectives of safety for workers and the public.

Following the construction and installation guidance provided in the other chapters of this Blue Book shall in general bring compliance with much of the GOs rules. However, users in the areas where the GO 95 and GO 128 apply will always need to check the precise clearance, separation and strength/loading values with the latest issue of those General Orders and specific local municipalities.



## 27 Optical Fiber Facilities (FTTX) - Deployment

### 27.1 General

The service demands of modern communications (*everywhere at any time*) helps drive the expansion of optical fiber based networks to provide the necessary capacity (high-speed and bandwidth for downstream and backhaul traffic) to serve the communications needs of many different customers. Optical fibers now serve a large variety of facilities, including:

- OSP node facilities inside telecom Huts, CEVs, larger cabinets of communications utilities and other service providers (ILECs and CLECs).
- Buildings or campus complexes with large or multiple commercial customers and businesses with high capacity needs.
- Large cell/wireless facilities where Fiber-To-The-Antenna (FTTA) can provide direct connection to the pole- or tower-mounted antenna, in addition to the more typical FTTN service to a ground-based hut, cabinet or building where the opto- electronics and interconnection/distribution services are located (see

[Chapter 15](#) for discussions on wireless-specific issues, and [Section 23.5](#) for guidance on microtrenching).

- Directly into single family residences (FTTH and FTTC) through a network of large and small fiber distribution hubs, interconnection panels, and fiber splice points. These network architectures require placing fiber cables and equipment into huts, cabinets, pedestals, handholes, and vaults as well as aerial closures mounted on poles and strands.

The installation of these distribution and service optical fiber cables generally follows the same rules and procedures as with the installation of copper cables in the outside plant, which has been discussed in the earlier chapters of this [Blue Book](#). However, there are some important differences that require extra caution and care when installing optical fiber plant because of the high communications capacity traveling over a single fiber and the mechanical sensitivity of the small diameter glass fiber to bending and compression stresses.

Recent network architecture trends and service demands have resulted in the expansion of installation and construction techniques, including:

- A. The use of factory terminated cables with pre-connectorized service drop cables or splices
- B. Wider use of All Dielectric Self Support (ADSS) fiber cable to help accelerate fiber build-out in aerial plant applications, along with overlashing of existing cable spans

- C. Use of microtrenching techniques to accelerate direct-buried fiber deployments (fiber inside bundled microducts) along roads to serve facilities on poles, tower, and cabinets within FTTA and FTTC architectures
- D. The placement of cables and fibers into microducts and bundled microduct pathways for servicing from demarcation points into customer premises applications.

All these developments run the risk of increasing congestion in aerial (e.g., on poles) and underground plant where multiple joint users are competing for available space in the ROW or easement. These multiple users can include power utilities, communications companies (CLECs, ILECs, CATV and wireless carriers), traffic monitor/controls, light rail and other stakeholders supplying services to the local community.

This [Chapter 27](#) covers the proper handling and placement of outside plant optical fiber cables and discusses the various placement methods with a specific focus on the significant differences between optical fiber cable and metallic cable placements and handling.

### 27.1.1 Product Acceptance and Shipment

Any optical fiber cable suspected of physical damage during shipment shall have its optical fibers evaluated through testing with an Optical Time Domain Reflectometer (OTDR) prior to the cable's acceptance into stock. Visible indications that would initiate such optical loss measurements using the OTDR include:

- Deep or long abrasive scuff marks on cable jackets
- Dents, creases and crazes in the jacket, often evidenced by stress-whitening marks on the cable jacket
- Impact and puncture damage to cables or reels that indicate the product may have been struck with forklift blades or dropped during transit.

A visual indication may not always show or represent the extent of the damage. The cables should be tested by the cable manufacturer prior to shipment, and the results of that test should be available in the documentation provided along with the cable. The test data should either be as part of packaging materials, and/or be provided in a separate data package supplied to the product procurement group of the communications service provider/network builder.

The available optical power signal available at a given point in the span or at a node facility is reduced by optical loss in the fiber, reflection losses at splices and connections, chromatic dispersion and Polarization Mode Dispersion (PMD) pulse spreading (see [Section 27.1.1.1](#) for PMD discussions). An optimized optical budget allows the fastest and most reliable data transmission speeds across the fiber span, intermediate splices



and connections using the most cost-effective transmitters and sensitive receivers. The following are general rules for these as-received and as-installed cables:

- OTDR analysis should show that along any fiber within the cable there should be no point discontinuity with a measured loss greater than 0.10 dB or a reflectance greater than -55 dB at 1550 nm, and
- There should be no visible kinks along the cable, or significant physical damage that penetrates the cable jacket and exposes the cable core to outside weather, ingress of water or other contaminants.

It is assumed that any optical fiber cable being used has met the relevant product functional performance criteria of industry standards such as GR-20-CORE, *Generic Requirements for Optical Fiber and Optical Fiber Cable*; GR-409-CORE, *Generic Requirements for Indoor Fiber Optic Cable*; or GR-326-CORE, *Generic Requirements for Single-Mode Optical Connectors and Jumper Assemblies*, or another equivalent industry product standard. These GRs contain functional requirements to help ensure that proper packaging and transportation protection is used along with quality assurance programs (ISO 9000/TL 9000). In addition, the intrinsic design requirements in these GRs will help provide the necessary physical protection and mechanical robustness for the cable to withstand construction, installation and long-term placement stresses (bending and compression forces) without degradation in optical transmission capacity of the optical fibers protected in the cable core.

#### 27.1.1.1 Polarization Mode Dispersion (PMD) measurements

The effect of Polarization Mode Dispersion (PMD) along an optical fiber results in pulses of different polarization modes traveling at varying speeds along a single mode fiber. The end result is that optical signal pulses spread out over time and span length, thereby increasing the bit error rates of transmission. General guidelines for maximum PMD values recommended for a given transmission bit rate are given in [Table 27-1](#).

**Table 27-1 PMD Guidelines**

| <b>Bite Rate (Gbps)</b> | <b>Maximum PMD (ps)</b> | <b>PMD Coefficient (ps/km<sup>0.5</sup>)</b> |
|-------------------------|-------------------------|----------------------------------------------|
| 2.5 --> OC-48           | 40                      | < 2.0                                        |
| 10 --> OC-192           | 20                      | < 0.5                                        |
| 20 --> OC-384           | 10                      | < 0.25                                       |
| 40 --> OC-768           | 2.5                     | < 0.125                                      |

The lower the PMD in picoseconds (ps) and the lower the PMD coefficient is, the lower the dispersion between optical modes and the lower the bit error rates.

Therefore, PMD values may be useful to measure and report particularly for high bit-rate systems (i.e., > 10 Gbps) or for systems where it is anticipated that future transitions to higher bit rates are expected.

Because PMD values are sensitive to external stresses such as would occur during the cabling process, cable placement, temperature, and normal stresses from an OSP environment, the values reported in cable audits are of limited value. Statistical approaches are used during manufacturing quality checks to help ensure PMD is controlled. PMD measurements of installed fiber spans can be a useful verification of the capability of fiber link to be upgraded in the future to higher transmission rates.

#### **27.1.1.2 Bend-Resistant Fiber**

The development of bend-resistant optical fibers has enabled fiber placements in more congested locations and helped limit fiber damage during the mechanical stresses inherent in cable placement and installation. The larger benefit has been providing for more options and configurations in splice trays, connector fan-outs and fiber termination hardware where older traditional fibers would have been likely to experience microbending losses. Although the individual fibers may be more bend resistant, the cables shall still follow the tensile loads and bending restrictions noted in [Section 27.1.3](#) to avoid permanent damage and elevated optical loss in the cable.

### **27.1.2 Security and Safety Practices**

The cable shall be handled according to the manufacturer's instructions at installation and testing. The minimum bend radius of the cable shall not be violated. Proper safety precautions should be taken in handling the cable ends. All end caps shall remain on the cable. Exposed ends shall be covered to prevent an individual from touching the cable end and embedding a glass fragment into their skin.

While working with a terminated fiber cable, a technician should always handle the cable and drop, assuming that it is operational (i.e., emitting a laser signal), unless it has been verified to have no signal by an optical instrument.

Below are general safety guidelines to follow while working with optical fiber plant.

- An employee should not stare into the fiber end or connectors that terminate a cable.
- Employees should not view optical fiber emission directly with an optical instrument such as a microscope, magnifying glass or loupe eye.
- Verify with an optical fiber meter that the fibers to be worked on are not emitting a laser signal.
- Protect all exposed optical connectors with clean dust caps at all times.

- Avoid picking up pieces of optical fibers with bare hands. Use tweezers or sticky tape to pick up and discard loose fibers.
- Clean hands after handling optical fibers to help avoid possible skin irritation.

Individuals working with fiber cable should be familiar with the basic optical safety documents and guidelines such as:

- ANSI Z136.1, *American National Standard for the Safe Use of Lasers* – The parent document of the ANSI Z136 series of laser safety documents with recommendations for the safe use of lasers and laser systems that operate at wavelengths between 180 nm and 1 mm (the current edition is from 2014).
- ANSI Z136.2, *American National Standard for Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources* – Provides guidance for the safe use, maintenance, service and installation of Optical Fiber Communications Systems (OFCSs) utilizing laser diodes or Light Emitting Diodes (LEDs) operating at wavelengths between 600 nm and 1 mm. Optical communications systems include end-to-end optical fiber based links that usually use transmission wavelengths of 850, 1300-1310, 1550 and/or 1625 nm), fixed terrestrial point-to-point free-space links (using 0.3 to 1 mm wavelengths), or a combination of both. The current edition is dated 2012.

### 27.1.3 Optical Fiber Cable Placement

The installation of optical fiber cables generally follows the same rules and procedures as with the installation of copper cables in the outside plant. Much of this information can be found in the applicable chapters of this [Blue Book](#), such as clearances, manhole ventilation, NESC requirements, etc. There are some important differences, however, that require additional caution and care when installing optical fiber plant. This section addresses generic concerns to consider and recommended actions to take while working with fiber plant. Below are fundamental precautions while working with optical fiber cables to avoid physical damage of the plant:

- Always verify tensile strength from the optical cable manufacturer. Pulling tensions should not exceed 600 lbs, and are generally much lower (usually 100 to 200 lb maximum).
- Optical fiber cable under no tensile load should not be bent to a radius less than 10 times its own diameter.
- Fiber cable under tensile load should not be bent to less than 20 times its cable diameter.

See Section 23.8 for a case study of pulling optical fiber cable through a conduit or duct.

## 27.2 Underground Cable Placement

A clear communications path must be established and maintained between the cable feeding location, the cable pulling location and equipment, and all manned intermediate manholes or handholes during the pulling operation.

**! CAUTION !** *Workers should not enter a manhole or remain in a manhole during the placing or removing of any cable except under the following conditions:*

- To provide manual assist for optical fiber cables in intermediate manholes. Do not provide manual assist in intermediate manholes rigged with blocks or sheaves.
- To observe the alignment of equipment. The employee should remain clear of the equipment.
- To assist in the smooth passage of the cable. Keep all fingers and hands clear of innerduct openings.

As optical fiber networks are deployed deeper into the local loop towards the customer premises, smaller diameter cables with lower fiber counts are being deployed. These optical fiber cables necessary for the FTTx architectures discussed in [Section 27.1](#) may be better served using smaller diameter, more flexible duct products. A large variety of such products and configurations is being used to provide a protected pathway for these various fiber cables serving antenna sites, cabinets, splice cases, handholes and customer premises. This includes separate conduits, individual innerducts within conduits, flexible fabric sleeves, and single or bundled microducts.

### 27.2.1 Pre-Survey

The pre-survey of an optical fiber cable route is an integral part of the engineering and construction of the route. Pre-survey begins with route selection and continues through the installation of the innerduct. Any problem areas encountered or special requirements determined during innerduct planning and placing must be considered and noted on work instructions during planning for the cable-placing operation and be noted on any work instructions.

Examples of what conditions should be noted and planned for include the following:

- 90-degree turns in manhole runs where cable would have to be pulled from as a midpoint in the run or spliced location.
- When possible, avoid busy intersections for placing and splice setups.
- Conduit and duct selection is critical to avoid crossovers with existing cables and to keep consistent and logical duct routes. Optical fiber cables and copper cables shall be separated in different innerducts, if

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not in different conduits, to facilitate better cable management and avoid complications owing to the different cable characteristics.

- Look for the longest runs between manhole distances to reduce splice points along the route.

Optical fiber cables are normally ordered in specific lengths. The cable lengths are determined by measuring between splice locations, including allowances for racking in all manholes and normal storage in handhole, cabinets, or closures plus a minimum of 20 feet of excess, with 50-60 feet being preferred. Check with the design engineer as to the length of storage cable needed. Generally, enough cable slack is required to bring cable out of a manhole to a splicing van that can be parked at a safe location. Maximum cable lengths are limited by reel capacities. After the cable is installed, the excess is coiled in the splice manhole, cabinet or designated storage location.

During the pre-survey, the physical, regulatory and jurisdictional surroundings need to be evaluated as to the possible hurdles and comparative time/costs estimated for the different possible deployment methods that can be used. One should consider all of the techniques discussed in previous sections of this *Blue Book* to determine which is the most effective and efficient for the purpose.

- Aerial placement involving overbuilds and over lashing. See Chapters 3 through 14.
- Underground placement using available conduit space. See Chapters 16 through 20.
- Buried Plant with a wide selection of possible techniques depending on the urban, suburban, and rural nature of the surroundings, as well as density of obstacles and other underground utility plant in the available ROWs.
  - General trenching and plowing methods. See Chapters 21 through 23.
  - Directional drilling to minimize excavation disturbance. See Chapter 24, in addition to the general parts of Chapters 21 through 23.
  - Microtrenching methods to minimize costs in congested urban environments. See Section 23.5.

### 27.2.2 Tools and Equipment

Optical fiber setups in the pulling and feed manholes, the sheaves, pulling frame, etc., are the same as those used for all underground cable placing. Some tools and materials specifically required for placing underground optical fiber cable are described in Table 27-2.

**Table 27-2 Summary of Underground Tools for Optical Fiber Cable Placement**

| <b>Tools</b>                     | <b>Use</b>                                                                                                                                                                                                           |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Innerduct/Cable Slitter          | Used for slitting innerduct longitudinally.                                                                                                                                                                          |
| Innerduct Coupling               | Used to join sections of innerduct through an intermediate manhole, to extend innerduct in a manhole, and to repair innerduct.                                                                                       |
| Winch                            | Provides the cable placing force to pull the cable into innerduct. Often, the winch incorporates a means (tension brake) to control the placing force so the maximum allowable pulling tension will not be exceeded. |
| Optical Fiber Cable Feeder       | Guide for winch line and cable into innerduct. One end is flared and the other belled to fit over the innerduct.                                                                                                     |
| Flexible Pulling Eye             | Factory installed on some ribbon-core optical fiber cables to protect factory-prepared cable ends.                                                                                                                   |
| Innerduct Cutter                 | Used to cut innerduct.                                                                                                                                                                                               |
| Basket Grips                     | Flexible wire-mesh cable holding devices for cable placing. Used whenever a factory-installed pulling eye is not provided.                                                                                           |
| Optical Fiber Cable Bending Shoe | Used to protect and rack optical fiber cables. Made from 40 mm PVC pipe, split to allow for installation. Available in straight sections or 90-degree bends.                                                         |
| Optical Fiber Cable Storage Form | A mandrel for winding excess cable into a coil for storage. The form will collapse, enabling the coiled cable to be removed for storage.                                                                             |
| Pulling Line                     | Winch line for pulling optical fiber cable. Often a high-strength, low-stretch tape will be used.                                                                                                                    |
| Swivel Connector                 | Used to relieve any torsional imbalance between the winch line and the cable during cable placing.                                                                                                                   |

In addition to traditional pulling techniques used for cable placement, there are also blowing techniques that are discussed in [Chapter 22](#).

### 27.2.3 Fusion Splicing Optical Fiber Cable in Cable Entrance Facilities (CEFs) and Manholes

Fusion devices differ from other spark-producing equipment or open flames in that the arc is under continuous control and observation by the operator, and there is no combustible material (polyethylene sheath, muslin, or pulp insulation) in the immediate area where the arc is produced.

Fusion splicing can be safely performed in manholes and CEFs if the following requirements are met:

- Testing, purging, and power ventilating requirements are followed as described in this section.
- A suitable continuous gas monitor is used to detect combustible gases.
- The procedure is approved by the communications company work practices.

See Chapters 16 and 17 for further procedures and guidelines for working in manholes.

### 27.2.4 Innerduct

Innerducts are 1-inch to 1-1/2-inch Inside Diameter (ID) plastic pipes that provide a smooth sealed path for optical fiber cables. Innerduct also subdivides underground conduit into compartments to house additional cables. Innerduct, lubricant, couplings, cable, and placing equipment all form a family of materials that must be compatible and properly matched together to optimize the cable-placing operation.

The following rules can generally be applied to size innerduct or microducts for cables:

- For the High Air-Speed Blowing (HASB) method, the innerduct-to-cable diameter ratio should be 2:1, or greater. That is,  
—  $(\text{Innerduct Inside Diameter})/(\text{Fiber Cable Outer diameter}) > 2$
- For other pulling methods, the innerduct-to-cable-diameter ratio should be 1.5:1, or greater. That is,  
—  $(\text{Innerduct Inside Diameter})/(\text{Fiber Cable Outer diameter}) > 1.5$ .

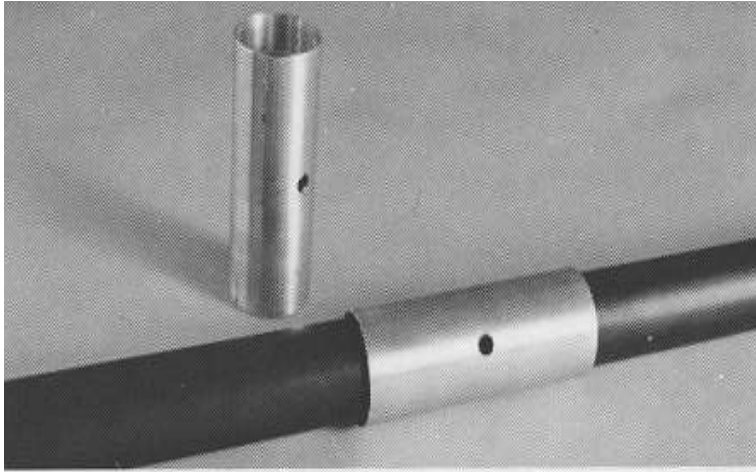
### 27.2.5 Standard Innerduct Coupling for Pulling Method

An innerduct coupling can be used to join two lengths of innerduct in a manhole to make it continuous through the manhole. Often, it is necessary for innerduct to be continuous through a manhole during cable placing. The



innerduct coupling is made from anodized aluminum or similar non-corrosive material and threaded internally with opposite threads so that it can be screwed onto the ends of two innerducts.

**Figure 27-1 Example of Innerduct Couplings**



General installation instructions for the coupling are as follows:

1. Cut the ends of the innerduct with an innerduct cutter. Be sure the ends are square and smooth to promote smooth threading of the innerduct into the coupling and full proper seating of the innerduct fully into the coupling.
2. Position the coupling on one innerduct end and turn the coupling on the end of one of the two innerducts to be joined.
3. Insert the other innerduct end into the coupling and turn the coupling by hand until the threads have started on that end.
  - It is convenient to mark the appropriate depth (1/2 length of the coupler) to which the innerduct should be screwed into the coupler to be fully seated.
4. Use a hand tool (e.g., strap wrench or large pliers) to turn the coupling until the ends of the innerduct are butted against each other. Hydraulic coupling tools are available, but it may often be difficult to maneuver the devices into, and use in, trenches and manholes.
  - It is important to keep the innerducts as straight as possible during tightening to maximize the strength and water resistance of the coupling.
  - If cross threading damage occurs to the innerduct or coupler during the tightening process, remove the coupler and restart the process at Step 1 above with a new cut end and coupler, if feasible.



Three or four innerducts may be placed in each 4-inch conduit; however, cable pulling tensions may increase if four innerducts are used. [Table 27-3](#) shows the maximum number of innerducts that can be placed in a conduit, and the maximum cable diameter that can be placed in the innerduct.

**Table 27-3 Innerduct Utilization**

| Maximum Cable Diameter<br>in millimeters (Inch) | Innerduct Size<br>in millimeters<br>(Inch) | Number of Innerducts per Conduit (Notes 1 and 2) |                              |                                |                                 |
|-------------------------------------------------|--------------------------------------------|--------------------------------------------------|------------------------------|--------------------------------|---------------------------------|
|                                                 |                                            | 100 mm<br>(4 Inch)<br>Round                      | 100 mm<br>(4 Inch)<br>Square | 90 mm<br>(3-1/2 Inch)<br>Round | 90 mm<br>(3-1/2 Inch)<br>Square |
| 17 mm (11/16<br>inch)                           | 25 mm<br>(1 inch)                          | 3                                                | 4                            | 3                              | 3                               |
| 24 mm (15/16<br>inch)                           | 32 mm<br>(1-1/4 inches)                    | 2                                                | 3                            | 1                              | 2                               |
| 26 mm<br>(1-1/16 inches)                        | 40 mm<br>(1-1/2 inches)                    | 1                                                | 2                            | 1                              | 1                               |

**Notes:**

1. The conduit system must be verified to be in good (clean, dry) condition before placing this maximum number of innerducts stated here, i.e., inspected and rodded if necessary.
2. The maximum cable pulling distances may be reduced in ducts containing more than 1 innerduct.

[Figure 27-2](#) shows a typical pulling eye sling setup for pulling multiple innerducts through a conduit.

**Figure 27-2 Pulling Eye Setup for Multiple Innerduct Placement**

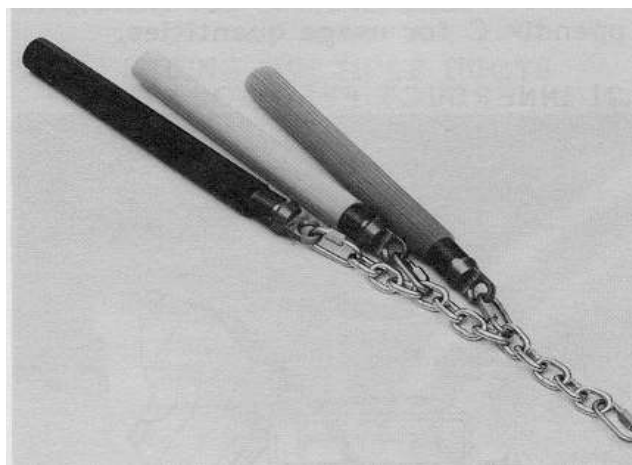


Figure 27-3 shows a basket-type cable grip to firmly grab a 1- to 2-foot section of the outer cable jacket through frictional forces while keeping the compression forces on the cable core as low as reasonably possible.

**Figure 27-3 Basket-Type Cable Grips**

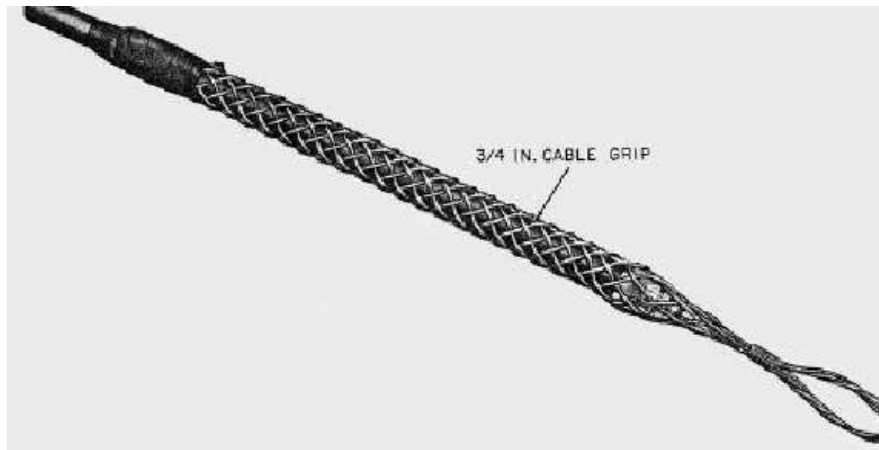


Figure 27-4 shows a swivel connector used during optical fiber cable placement to minimize torsional (twisting) forces placed on the cable jacket and cable core components during placement.

**Figure 27-4 Swivel Connector for Optical Fiber Cable Placement**



In general, lubrication should be used for all optical fiber cable pulls. The cable lubricant should be applied as the cable is pulled into the innerduct. At cold temperatures, special low-temperature lubricants may be needed. Pour or pump the lubricant into the raised end of the innerduct ahead of the swivel connector so the swivel connector distributes the lubricant as the cable is pulled in. Use approximately one liter of lubricant for each 100 meters of pull. An appropriate amount of lubricant should be applied at each manhole.

**Note:** One exception is during some HASB or air blowing deployment operations where lubrication may interfere with frictional wheels and grips used to provide the forward feed push to cable.

**Figure 27-5 Cable Lubricant and Hand Pump**



**! WARNING!** Liquid detergents shall not be used as lubricants for placing optical fiber cable. Many detergents can promote stress cracks when used on polyethylene.

Figure 27-6 shows apparatus used to provide lubricant at the intermediate manhole location while allowing the technician to remain at a safe distance from the cable/ innerduct entry point during placement.

**Figure 27-6 Intermediate Manhole Cable Lubricator**

**Note:** Be careful not to create cable loops in the feed manhole that could snag on cable racks, hooks, ladders, etc. Do not permit slack loops to form on the cable reel.

Manual assist may be required in intermediate manholes if the pulling tension threatens to exceed the maximum rated pulling load for the cable. Be sure not to exceed the pulling tensile strength of the cable. Generally, the pulling tensile strength of the cable ranges from 300 to 600 lbs. If manual assist is anticipated, the assist crew should be in position in the intermediate manholes before the pull begins. If manual assist is required in intermediate manholes, a 3- to 6-foot gap must be made in the innerduct to assist the cable.

### 27.2.6 Occupied Conduits and Separate Ducts (Innerducts)

While it is common practice to use the terms duct and conduit interchangeably, in the NESC they have distinct definitions. Duct (or innerduct) is a single enclosed raceway for conductors or cable; conduit is a structure containing one or more ducts; and conduit system is the combination of duct, conduit, conduits, manholes, handholes, and/or vaults joined to form an integrated whole. Therefore, the conduit practices will be covered by the general rules of the NESC (e.g., General Use clause Rule 012) in combination with the specific underground rules of Sections 30, 31, 34 and 35 for the buried conduit, as well as Section 36 for vertical risers that transition from underground to aerial (pole-mounted) plant.

Although the concept of placing multiple communications cables from different companies inside a single duct or conduit is permitted in the NESC and other industry practices, such a practice is not considered a standard or traditional practice and, therefore, multi-occupancy of ducts is only

permitted if all affected parties and utilities are

- (a) notified,
- (b) in agreement, and
- (c) have well-defined and mutually agreed upon working procedures for this joint-use plant.

The safety and reliability rules of the NESC are explicitly built on:

- Cooperation and formal agreements between joint users of facilities attached to poles, in aerial spans, and in below-ground/underground spaces.
- Separation and clearances between cables and equipment. This principle applies between supply and communications equipment, as well as between the communications cables of different utilities and companies.

The objectives and intent of these NESC rules are to help ensure the safety of people (public and workers) and to maintain service reliability through avoiding interference and damage to adjacent and nearby facilities. In new construction, this would be best accomplished with separate ducts (innerducts) being placed inside the conduit. An example for services provided to a commercial building or large multi-dwelling (MDU) apartment block could use 3 x 1.5-inch diameter ducts inside a 4-inch diameter conduit. The three (3) ducts could be assigned as follows:

- A. Duct #1 – Designated for twisted-pair or coaxial copper cables for current or requested services to the multiple customers present in the building.
- B. Duct #2 – Designated for optical fiber cables for requested services to the customer. This second duct would be designated for broadband services that require the fiber cabling to provide the desired transmission rates or for secondary fiber cable to provide enhanced services. It is common practice to use separate ducts for optical fiber cable and copper pair cable to avoid possible damage to the high bandwidth fiber cable, and this duct #2 could be assigned as an optical fiber cable duct.
- C. Duct #3 – Designated as a spare duct for future use to expand services or the addition of new users/customers as requested by the customer and/or anticipated by the service provider based on experience, demographic predictions or known development plans. Another company would use this spare duct under a contractual agreement or lease between the initial conduit provider or the customer, depending on who owns the conduit.

Maintaining separate ducts (innerducts) avoids the dangers of placing a new cable into a duct or conduit that already contains an installed cable that greatly increases the probability of damage to all the components; i.e., the existing installed cable, new cable being placed, and the conduit/duct. The

different pulling tensions, bending characteristics, and abrasion resistances of these different cable types results in an industry best practice to separate them in cable trays, raceways, conduits and ducts. One of the industry's standard guideline documents for placement of fiber cables in network facilities is GR-1275-CORE, *Central Office/Network Environment Equipment Installation/Removal Generic Requirements*, where optical fiber cables are required to be maintained separate from other cable types with physical barriers, i.e., separate ducts. Pulling one cable over another is likely to create a high friction pathway that will lead to high significant tensions, abrasive damage and compression stresses. The mechanical stresses that occur during the installation process can also initiate cracks and surface damage to older conduits and ducts.

Optical fiber cable will usually be pulled into an innerduct liner or conduit which may be a smooth bore or a corrugated liner. The typical coefficient of friction for pulling lubricated cable into smooth bore is 0.25 and 0.20 for a corrugated duct liner. Such suitable liners are recommended to maximize the length of optical fiber cable that can be placed in a single pull. In general it is recommended that three duct liners be the maximum number placed in a 3-1/2 or 4-inch diameter conduit/duct where long cable pulls are to be made otherwise the effective coefficient of friction will increase.

The tensile load rating specified (by the manufacturer) for optical fiber cable is the limiting tensile force to which the cable can be subjected without risking fiber damage. The maximum pulling distance varies in inverse proportion to the friction coefficient. The actual bends, curves and changes of direction of a conduit run can be modeled by assuming a continuous large radius curve that is based on the following equation.

$$T/W = 127 \cosh (f \times L/360) + 382 \sinh (f \times L/360)$$

where,  $f$  = coefficient of friction

$L$  = distance cable is pulled in feet

$W$  = unit weight of cable in pounds per foot (lb/ft)

$T$  = Tension Force in pounds (lbs)

See Section 23.8 for calculation details of the pulling forces needed to install cables into ducts and conduits with optical fiber cable examples in Section 23.8.2. The calculated limits on pulling distances for a given cable and duct system can be extended to longer placements through modifying factors designed to reduce the pulling forces by reducing friction while staying well under the desired pull strength of the cable. These factors include:

- Keeping cable runs as straight as practical - minimize bends or make them as large a radius as possible and practical.
- Using lubricants to reduce friction.
- Modifying the internal surface design (shape and/or coating material) of the conduit to reduce friction.

- Using larger conduits and/or smaller fiber cables to reduce frictional forces.
- Using air-blowing systems to float and/or blow cable through conduit rather than pull it through the run (see Chapter 22).

### 27.2.7 Microducts and Fabric Sleeves

As optical fiber networks are deployed deeper into the local loop towards the customer premises, smaller diameter cables with lower fiber counts are being deployed. These optical fiber cables are better served using small diameter, more flexible duct products, collectively called *microducts*<sup>1</sup>. Single and bundled microduct products with individual tube diameters of as low as 5 mm have been introduced to maximize the use of available space in already-installed ducts and conduits. To minimize frictional forces, the inner walls of the microduct products can be smooth or grooved, as well as have low coefficient of friction coatings applied.

Microducts are small (5-20 mm diameter) ducts with thick walls that provide adequate mechanical robustness and protection to the optical fibers they contain. Bundled Microduct Products have several (i.e., anywhere from 2 to 24+) individual microducts combined together under a sheath(s), with these composite type products called “bundled microducts” or “microduct assemblies.” The overall dimensions of these bundled microduct systems can vary significantly with cross-sectional shapes from a traditional circular (round) shape, to polygon shapes, to flat rectangular shapes that are developed to suit specific applications, environments, and user needs (see GR-3155, *Generic Requirements for Single/Bundled Microducts and In-Living Unit (ILU) Cable Pathways* for details on functional performance criteria). These composite structures are assumed to have higher compression and impact resistance than the individual microducts they contain. The sizes, shapes, wall thicknesses, and designs available for these various microduct type products may require variations in the standard placement techniques and tools.

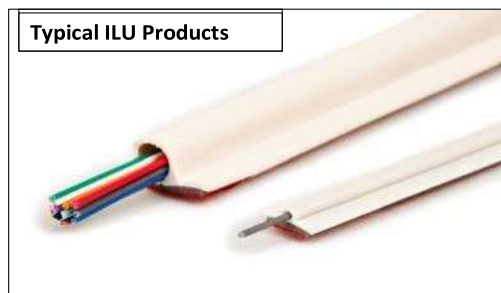
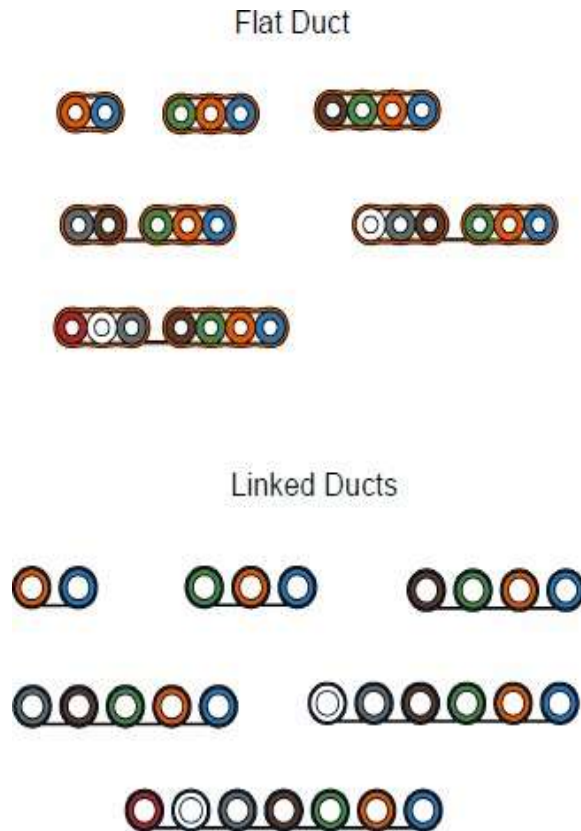
The overall dimensions of these bundled microduct systems can vary significantly with cross-sectional shapes, from a traditional circular (round) shape, to polygon shapes, to flat rectangular shapes that are developed to suit specific applications, environments, and user needs.

The flat and linked microduct configurations ([Figure 27-7](#)) are primarily designed with low profile shapes for easy and aesthetic installation inside buildings, crawl spaces, cable troughs, and along wall cavities. These products can be found for service drop and intra-building spans. There are also In-Living Unit (ILU) microduct sleeve designs with adhesive strips for more easy attachments to painted and finished walls inside apartments and similar living spaces.

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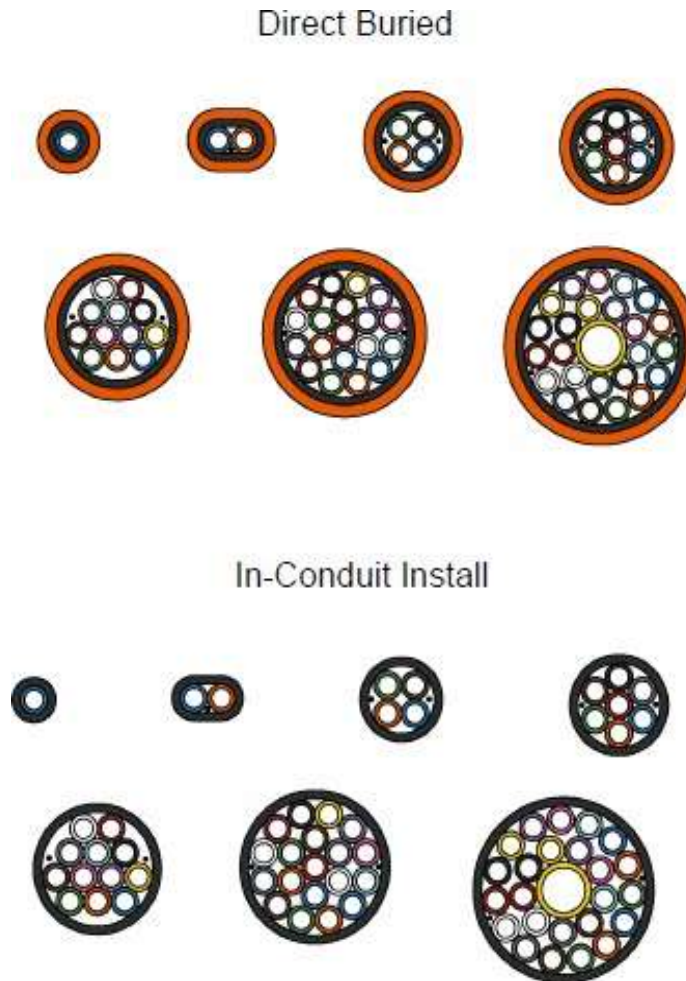
**Figure 27-7 Flat, linked and ILU Microduct Product Assemblies**

The flat microduct products with 2-4 individual microducts under a closed sheath have also been used inside the narrow trenches created in microtrench deployments. Such microduct products placed in shallow slits under roadways are susceptible to later damage from road-widening projects, re-surfacing activities and excavation by other utilities for work on their underground/buried facilities (also see [Section 23.4.3](#)).



There are microduct products for direct-buried applications that have thicker or double sheaths for greater mechanical robustness and protection compared to the in-conduit products that obtain their primary protection from being inside a conduit.

**Figure 27-8 Direct-Buried and In-Conduit Microduct Configurations**



These microduct assembly products with many individual pathways have been used for some Passive Optical Network (PONs) where individual dedicated fiber runs from (a) the central office or fiber distribution hub/cross-connection site to (b) the demarcation point at the NID on, or inside, the customer building. Although the practices and products described below in this [Section 27.2](#) are focused on the larger innerduct deployments of larger sized optical fiber cables, the general principles are similar.

Deployment of fiber cables or individual fiber drops through these microduct products vary along with the various pathway configurations; this includes using not only the traditional pulling tapes/ropes, but also more often with low stress, blowing techniques.

The microducts are more often found inside Multiple Dwelling Unit (MDU) installations and come with a range of appropriately sized and designed accessories, including their own set of seals, couplings, and plugs designs. In the microduct, usually only one cable is placed, with that cable containing a single optical fiber or some small number of fibers (less than 12 fibers). The pulling forces (3-15 lbs) and blowing pressures (up to 10-20 psi) used when placing cables in microducts are low compared to the 100 psi pressures for the innerduct examples discussed in [Chapter 23](#). Pulling tapes are used in microducts rather than the pulling eyes described in [Figure 27-2](#). The couplers used for microducts are typically plastic with O-ring seals, compared to the more mechanically robust metallic sleeves shown in [Figure 27-1](#).

### 27.2.8 Fabric Sleeves

Flexible lightweight fabric sleeves containing pull tapes were introduced as an alternative to maximize the use of available space in already-installed ducts and conduits and provide a convenient (less expensive) alternate to placing a new duct or conduit.

The collapsible fabric products are engineered with a low coefficient of friction so that low cable pulling tensions can be used as well as being available in various configurations, including multiple cells (1, 2 or 3), with or without pull tape, self-supporting, and different colors. Individual cells will accept up to a 1-inch diameter cable, which can provide great flexibility for some local distribution, service drop plant, and intra-building applications.

The open structure of these fabric sleeves can allow entry of water, dirt, soil, and other particulate contamination into the cable pathway, causing problems during cable installation. Smooth and corrugated ducts as well as microducts provide the preferred means to insert a separate smooth cable pathway into a conduit. It is possible for these fabric sleeves to provide a good cable pathway inside straight new conduit runs between manholes. However, the sleeves can have trouble snaking their way through conduits with numerous bends (such as conduit runs into and around customer buildings). In older conduits that have accumulation of soil, pebbles, water, and mud inside them, placement of cables in older contaminated sleeves have proven problematic.

## 27.3 Direct-Buried Cable

Before any excavation begins, all below-ground utilities must be marked out. This can be accomplished by the One-Call Center. Refer to [Section 2.8](#) of this *Blue Book* for more details on One-Call systems and general precautions appropriate to deployment of plant in buried networks.

Within direct-buried installations with FTTx fiber cables deployed alone, or in individual conduits, ducts or microducts directly buried in soil, there are several factors to consider, including:

- ROW and Easement issues can be complicated, particularly where other utilities are also present under the ground (power, water, gas, incumbent telecommunications, etc.)
- For direct-buried plant in trenches, the construction costs for trenching or drilling/boring operations can be significant. One option is to configure the service drops entering from the rear property line to lessen traffic disruption and reduce construction costs, but such an option can complicate access to plant and placement of drop services to the house.
- Microtrench deployments using fiber cables inside microducts placed under roadways or sidewalks can be placed rapidly. However, problems can develop since the cutting or plowing tools can only achieve rather shallow depths. Such shallow depths (6-8 inches practical maximum) can be a concern that can increase the possibility of damage and service disruption during later roadway or unrelated excavation work by utilities, DOTs and other users of underground plant.

Direct-buried placement in trenches as joint-use plant with other utilities enables shared construction costs with other companies. This deployment option is more often appropriate in Greenfield applications where construction coordination and cooperation is easier to achieve.

### 27.3.1 Depth of Cover

Buried plant should ordinarily be installed with sufficient cover to protect it from surface loads and future construction. Normally, optical fiber cable is buried at a depth of 30 and 24 inches. Where subsoil plowing is done (as in agricultural areas), the cable should be located at least 12 inches below the maximum depth attained by such agricultural equipment to avoid possible damage to the cable.

Refer to [Section 2.9](#), “Depth of Buried Plant,” and [Section 2.10](#), “Separation from Gas and Other Fuel Lines,” of this *Blue Book* for more details on the appropriate burial depth and safe placement of fiber cable relative to other buried utilities.

When crossing roads, highways, streets, and railroads, the depth of the plant should be sufficient to minimize the possibility of mechanical damage due to road grading or ditching activities and the usual maintenance work along the highway or railroad right of way. All installations shall conform to the local ordinances.

**Note 1:** When existing subsurface facilities are encountered, the optical fiber cable should be placed underneath the existing facility with, if possible, at least 1 foot of vertical separation.

**Note 2:** To facilitate future construction on the route, consideration should be given to placing a separate, empty capped conduit with the cable at all intersections with subsurface facilities and at points where permanent surface obstacles such as roads, streams, etc., are crossed.

A 4-inch diameter metal or rigid plastic conduit should be used under all permanent surface obstacles. The spare conduit should extend at least 9 feet on either side of the obstruction (in front of and beyond). Construction records should show the location of all such short conduits placed on buried cable routes.

**Note:** When working on a rough grade, the cable should be buried at sufficient depth and located so that the final cover for the plant will meet cover requirements after the permanent grade has been established. The required depth of placement under such circumstances will be shown on the work prints.

The microtrenching placement techniques noted in [Section 27.2.6](#) above that place the ducts and their cables at shallow depths (2 to 6 inches) may be an effective solution for light traffic zones along stable sidewalk or roadway areas that are unlikely to be disturbed for future roadwork or utility excavation activity. However, most roads, highways and sidewalks will require some such work along with the possibility of accidental dig-ups and other circumstances that would impact such shallowly placed plant. These shallow depths are not likely to provide adequate long-term physical protection for cables even when the cables are inside the duct. Supplementary protection is advisable since the added protection from having the cables being inside a duct (microduct) at a depth of 2-6 inches is insufficient to prevent immediate damage from the type of cutting tools and saws used for road work and utility.

For urban environments crowded with utilities and other buried facilities, it is critical that, before any excavation or roadwork, the underground utilities in the area are located and marked along with expected depths, as per [Section 2.8](#) and [Section 24.6.1](#).

For buried drop service wires, the depth of cover should be at least 12 inches, with an objective of 18 inches in depth since gardening and yard work, such as planting a small bush or erecting a fence, can easily cause surface disturbances to a depth of 12 inches or greater.

### 27.3.2 Pre-Survey

As with all cable-placing operations, a pre-survey is one of the more important procedures that will help ensure a safe, efficient, and successful cable-placing operation. Engineering and construction personnel should inspect the proposed route before starting construction. The location of the proposed plant will be designated on work prints and must be marked or staked out in advance. The limits of the ROW and easements may also be marked. All points that will require buried cable to be passed under intersecting obstacles must be marked, and consideration must be given to the work operation that will be required to complete the cable placement at each obstacle. The entire buried route must be marked with clear markers showing the location for cable placement and splice locations.

Soil conditions along the route should be determined and/or investigated before plowing. This will be helpful when selecting the equipment required for excavation and restoration. Drainage ditches or test holes dug along the route will reveal the general soil condition that will be encountered. The location of bridges, culverts, and subsurface utilities will be shown on work prints. The location of subsurface structures such as culverts and other buried utilities in the ROW should be staked in advance of plowing, and unless completely clear of the construction ROW, the structures, or utilities should be exposed prior to plowing.

### 27.3.3 Trenching Placing Method

The method of trenching prior to placing the buried cable will depend on the following items:

1. Soil conditions
2. Local topography
3. Route
4. Equipment available.

In most cases, it is economical to dig the trench using machinery. Never dig a trench that is deeper or wider than required. However, it is recommended that trenches not be narrower than 6 inches.

**Note:** In stable soil under normal conditions, shoring is required under OSHA Rule 1926.652(c), which covers trenches, pits, or excavations that are 5 feet or more in depth if people will enter them. More shallow trenches will also need shoring if unstable soil conditions exist, excessive rain occurs, or adjacent activity (heavy equipment use or traffic) can destabilize the trench walls.

Trenches in sandy soils have a tendency to collapse. For this reason, the cable or innerduct may have to be placed immediately behind the trencher.

When cutting across asphalt roads, begin trenching in the soil at the shoulder of the road. Restoration is generally governed by local regulations and must be completed in a timely manner consistent with local expectations.

It may be advantageous to push or drive a pipe instead of opening a trench, when buried plant must pass under shrubs, sidewalks, paved streets, etc. If a metal pipe is used, shielded cable should be bonded to it using one of the methods outlined in [Section 21.2.5, “Bonding and Grounding of Buried Optical Fiber Cable,”](#) of this *Blue Book*.

When working in an established lawn, carefully remove the sod so it can be replaced when the work is completed. Soil from the trench can be temporarily stored on plywood or tarpaulins to avoid damaging the lawn.

### 27.3.4 Cable Placing

The cable-rated tensile load and minimum bending radius must be observed at all times. Lay the cable on the trench bottom, being careful to observe the tension and bending limitations of the cable prescribed by the manufacturer.

**! CAUTION !** *The following general handling principles should be used during buried optical fiber cable placement to help protect the cable from **mechanical damage**.*

1. Do not exceed the minimum bending radius of cable.

**Note:** As a general rule, optical fiber cable under no tensile load should not be bent to a radius less than 10 times its own diameter.

**Note:** However, a fiber cable under tensile load should not be bent to less than 20 times its cable diameter.

2. Avoid equipment that will abrade the cable sheath.
3. Do not put a reverse bend in the cable during cable placement.

Unless specially directed by the project engineer, do not place innerduct as a spare conduit for feeder and distribution unless it is known in advance that the HASB cable placing method will be used. If a spare duct is to be installed at the time of cable placing, it should be rigid plastic with an inside diameter of at least 1-1/2 inches.

### 27.3.5 Backfilling and Ground Restoration

Backfilling is used to restore the appearance of the construction area, but more importantly backfilling is used to provide proper soil support around the cable to ensure its service life. It is necessary to properly compact all soil placed in the backfilling operation. The backfilling operation may be done

either by machinery or by hand, depending on local conditions, economics, and the equipment available.

The trench and the space outside splicing enclosures should be backfilled as soon as practical using quality backfilling materials and procedures that conform to local regulations.

In order to provide a good base and support for the plant, the first 12 inches of fill directly above the cable must be clean sand, crushed stone dust, or sandy soil. The fill should be free of rocks, pavement, and frozen material that might damage the communications plant. A trench filled with select granular material will compact more readily than one filled with coarse or rocky material.

Often the earth is mounded over the trench to compensate for future settling. Settling of the backfill can be a serious problem unless the fill is properly compacted during the backfilling operation. Trench settling should be avoided when restoring trenches that cross paved surfaces.

The best compaction results will be obtained by making two passes with a machine tamper after each addition of 8 to 12 inches of backfill. The backfill of a trench in an unpaved area may, in some cases, be satisfactorily packed down by running a crawler tractor or large rubber-tired vehicle along the trench on top of the backfill.

**Note:** Do not apply any compaction effort to the backfill until there is at least 12 inches of soil covering the communications plant.

If topsoil is removed from a trench, it should be replaced at the top of the backfill. If sod is removed, replace on top of the topsoil after the trench has been compacted and grade accordingly. At locations where there is danger of washouts exposing the cable or wire (such as on hillsides), a thorough tamping of the backfill will help prevent washouts. In severe washout areas, it may be necessary to use riprap or other means of holding the backfill.

**Note:** Riprap (also known as rip rap, rubble, revetment, shot rock, or rock armor) is rock or other material used to armor trenches or shorelines against water erosion.

All permanent pavement and sidewalks must be restored to the satisfaction of the proper authorities. When backfilling and soil compaction is finished, clean up the work area thoroughly.

### 27.3.6 Rollers and Guide Tubes

The cable feed rollers and feed system shall conform to the cable minimum bend radius for cables under tension (i.e., bending diameter shall be greater than 20 times the cable diameter). All hardware rollers, guides and chute should allow the cable to pass without increasing the tension in the cable. A feed tube or small diameter rollers may be used as cable guides. Cable guide systems often use small diameter vertical rollers and horizontal rollers.



Vertical rollers should be mounted so the smaller cables cannot become wedged between them and the horizontal rollers.

### 27.3.7 Optical Fiber Drop Plant - ONUs, Pedestals, and Handholes

As FTTx expands to the home, fiber cables and drops are placed through smaller closures and tighter spaces. Pedestals used as Optical Network Unit (ONU) nodes can be as small as 6 to 10 inches square. Handhole closures (Section 21.5) are boxes typically varying from 1 square foot in size up to larger boxes 2 to 3 feet in length and 2 to 3 feet deep that provide an access point for fiber cable drops and splices to distribution cables in FTTC and FTTH networks.

When using these closure access points, it is important to ensure that the cable loops and bends into and out of the pedestal or handhole, as well as the feeds into and out of the splice point (fiber terminal closures and strips), all comply with the minimum bend radii for the respective drop and distribution cables.

- An optical fiber cable not subject to tensile loading should not be bent to a radius less than 10 times its own diameter.
- An optical fiber cable subject to tensile loading should not be bent to a radius less than 20 times the cable diameter.

It is also important to have the fiber access stub terminal properly mounted and secured to the wall or mounting bracket within the handhole. Connection stub terminals should not be left lying on the ground or floor of the handhole.

Pedestals and handholes should also have adequate drainage systems designed with drain holes, sand/pea gravel laid in the bottom and, if possible, placement in an elevated position with respect to the surrounding ground level.

The threats to fiber cables in the drop plant include:

- Micro-bending losses in fiber caused by accidental kinking or compression of fibers or of the fiber buffer tubes at distribution, drop and breakout points in the network.
- Macro-bending losses caused by cable and drop congestion in the closure, which is indicative of multiple entries into a closure for cable re-work and trouble-shooting of cable. The fibers can become twisted, kinked or bent severely, which will induce optical transmission losses in the fibers.

The industry has responded to these dangers with the recent development of Bend Insensitive Fiber (BIF) or Bend Resistant Fiber (BRF) cables.<sup>2</sup>

**Note:** Current proposals are to distinguish jumper cables containing BIF or BRF fibers by using a different color (probably blue) from the traditional yellow jumper cables for the standard optical fiber products.

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However, the fundamental solutions to these concerns are a good cable management plan and practices to:

- Maintain appropriate bend radii at all points in fiber distribution and drop plant.
- Complete a pre-survey and develop a plan for a cable placement route to avoid over stressing and long-term strain to cable.
- Use proper mounting and attachment hardware.
- Include strain relief loops, fiber trays and sufficient slack in the cable run to avoid mechanical stresses.

Since one cannot visually determine what type of optical fiber (BIF or standard) is under a black jacket sheath, or what any particular optical fiber may be, it is wise to treat all optical fiber cable as described above, and not bend a cable to a radius less than 10 times its Outside Diameter (OD) where no tensile load exists, or to less than 20 times the cable's OD where tensile loading stress exists.

## 27.4 Aerial Cable Placing Method

Route planning and cable selection are technical considerations that are engineering responsibilities, but selection of the method used to place the cable is usually left to the construction forces. Selection of the placing method is just as important as any phase of the job. The objective is to select the method that imposes the least physical stress on the cable.

Some of the factors that must be considered are cable type, experience of the placing crew with the specific type of equipment that will be provided to them, availability of that equipment, terrain through which the cable will be routed (trees, other obstructions, strand location on road side or field side of pole, poles on public or private row, accessibility of vehicle to pole lead), unusual power hazards, and traffic density.

The FTTx aerial facilities may be placed on poles, towers or similar structures placed in various configurations, including the following choices:

- In the Communications Space below the supply power plant and above any existing telecommunications plant. If the FTTx fiber is the first joint attacher to the existing pole line, one needs to establish a joint-use agreement with the pole owner.
- In the Communications Space below the supply power plant and above the existing telecommunications plant as the second joint-user attacher to the pole where the preferred approach is to follow the existing joint-use agreement between the first joint-user attacher and the pole owner as a licensee.
- In the Supply Space [e.g., as an Optical Ground Wire (OPGW)] or above the supply power space (pole top) where we need to develop a joint-use

agreement with the power supply company. The installers and maintenance personnel for this configuration will need the appropriate skills and qualification for the electrical space. Fiber cable could be placed on transmission structures with ADSS cables, providing physical access issues are resolved.

- Build new dedicated sole-use pole line for the new fiber FTTx plant, resulting in higher capital costs for new poles and large construction activity that many communities will not appreciate.

The placement of new FTTX cables in aerial plant where joint-use space is available on installed poles, and is both possible and practical, is expected to be significantly less expensive than direct-buried or underground construction.

There are three main types of methods for placing aerial plant:

- Stationary reel (back-pull) – [Section 27.4.1](#)
- Moving reel without aerial lift (drive-off method) – [Section 27.4.2](#)
- Moving reel with aerial lift (drive-off method) – [Section 27.4.3](#).

Advantages and disadvantages of each are discussed in this document. The moving reel with aerial lift method has very limited application, and the constraints placed on its use should be observed.

### **27.4.1 Stationary-Reel Method (Backpull)**

The stationary-reel method is the only way in which the cable may be placed in field-side construction or when there are obstacles that obstruct access to the cable such as heavy tree growth. This stationary-reel method is often the first choice for placing crews since workers can be rapidly trained to competent levels. This method offers greater tolerance during the handling process of the fiber cable during placement, thereby avoiding mechanical damage.

The stationary-reel method should be the preferred method of choice for fiber cable placement. Under the right conditions, moving reel methods can be used safely and reliably with increased productivity.

### **27.4.2 Moving Reel Without Aerial Lift (Drive Off)**

This moving-reel method is not as labor intensive as the stationary method in that it is not necessary to handle large numbers of cable blocks. However, to efficiently place fiber cable by the moving-reel method one needs to meet several conditions:

1. Minimal interference from large trees or heavy vegetation. Manipulating around trees and vegetation significantly slows progress and greatly reduces any increases in productivity that were expected.

2. Availability of having sufficient workers and drivers with the necessary ability to actively monitor and control the alignment of the reel and the strand lead.
3. Availability of having sufficient workers to actively monitor and control the proper alignment of the cable chute to prevent excessive bending or compression damage to the fiber cable at this critical point.

To use this moving-reel method safely and efficiently, careful attention needs to be given to the available personnel and equipment, as well as to the particulars of the cable route.

### 27.4.3 Moving Reel with Aerial Lift (Drive Off)

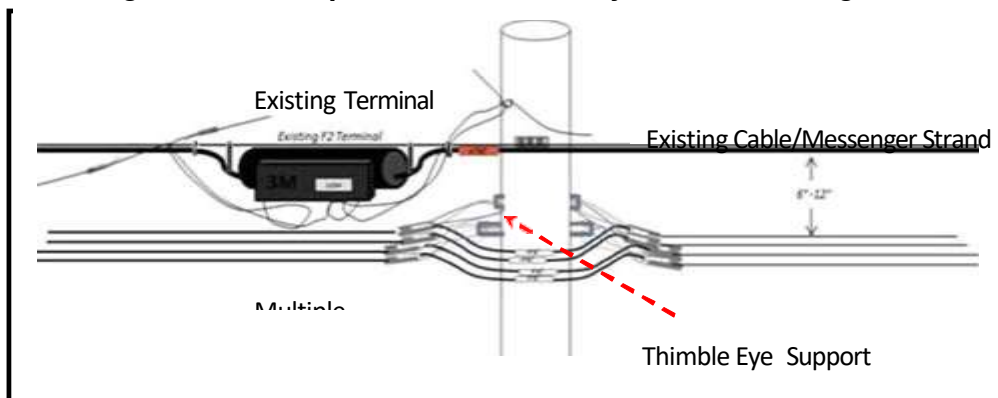
Another moving-reel method entails the direct use of an aerial lift for placing cable, and this method has proven to be profitable in placing copper and fiber plant, particularly self-supporting cable. However, as noted above in [Section 27.4.2](#), optical fiber cable is sensitive to bending and kinking, and there are significant risks associated with the fiber cable as it passes around the fair leads on the bucket. The conditions listed above in [Section 27.4.2](#) apply more emphatically to this moving-reel method since the operational tolerances are greatly reduced and the fiber cable can easily be damaged.

Because of the significant probability of cable damage during this moving-reel method, it is recommended that this method of placing should generally be avoided.

### 27.4.4 All-Dielectric Self-Support (ADSS)

The increased demand for broadband services has encouraged more rapid and less expensive deployment strategies to be used, including the use of lightweight ADSS fiber cables (also called Flexnap cables) for over-builds. One economic configuration for a straight pole line situation would be to use thimble eye bolts and cable clamps as shown in [Figure 27-9](#).

**Figure 27-9 Multiple ADSS Cables Adjacent to Existing Plant**



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The in-line configuration shown will maintain the minimum 12 inches of separation from existing plant at the support with the appropriate sags and tensions configured to match the existing cables and maintain at least 4 inches separation from existing plant across the span. As a general guideline, several of these lightweight ADSS cables can be hung on a single 5/8-inch thimble eye with mechanical wedge clamps. The pull strength of the cables (600 lbs) and tensions required for the heavy, medium and light loading districts are such that the applied load is far less than the working strength of the thimble eye hardware.

Difficulties can arise for this design choice if (a) the cables and attachment hardware add too much to the congestion on the poles and interfere with working space and ready access to other facilities on the pole, and/or (b) corner poles have significant pulls on the pole. The pull on corner poles can cause a problem for some of this hardware because of the possible creation of multiple holes that one may need for the various attachment hardware for:

- A. Existing lines
- B. Installed or additional guys necessary to balance any pull on the pole since it is a corner pole
- C. Holes for the new hardware for ADSS cables.

One needs to ensure these multiple holes are not too numerous and not too close together to compromise the pole strength.

Some users incorrectly advocate the use of J-hooks for use with the ADSS cables. These J-hook pole attachments are only suitable for temporary support during installation and only for straight line construction. They should not be used as permanent attachment hardware or for spans that cross roads. There are too many opportunities for the cable to come out of the J-hook under the effects of winds, particularly at corner poles and on those with pulls on them. The attachment is not secure and we should be using thimble eye bolts with attachment clamps to secure the cable to the pole.

## 27.5 Pole-Mounted Cabinets

Pole-mounted cabinets provide technicians important network access to the optical fiber feeder and distribution plant. It is important for public safety, the protection of the technician and the OSP facility that cabinets are placed correctly, securely, and in the proper location. The following subsections provide general guidelines for the placement of pole-mounted cabinets.

See Chapters 14 and 15 for recommended locations for auxiliary powering, interconnection and splicing cabinets/closures mounted on poles to support wireless and fiber broadband facilities.

### 27.5.1 Pre-Planning

1. Choose a site for installation that conforms to all local codes. If permits are required, they should be obtained prior to installation.
2. The installed cabinet must not create a visual or physical obstruction to vehicular or pedestrian traffic or block climbing access.
3. If the cabinet's distribution and feeder cables are to be routed up the utility pole to an aerial splice closure, the cables may be protected by installing conduit between the cabinet and splice closure.

### 27.5.2 Mounting the Cabinet

1. Prepare to place the cabinet at the prescribed location.
2. Place the cabinet top support bracket in position for mounting on the pole. The bracket should be provided with the cabinet.
3. Mark the location of the top support bracket mounting hole on the pole.
4. Drill a 5/8-inch hole into the utility pole at the point marked in Step 3.
5. Secure the top support bracket to the utility pole using a threaded rod or through-bolt, flat washer and nut.
6. Using the appropriate lifting equipment, hoist the cabinet into position for attachment to the utility pole.
7. Hang the cabinet from the installed top support bracket. The hanger bracket on the rear side of the cabinet slips over the installed top support bracket.
8. Check the cabinet to make sure it is level and then, using the cabinet bottom support bracket as a template, drill a 5/8-inch hole into the utility pole. Some cabinet manufacturers require the use of a 5/8-inch lag bolt to secure the bottom.
9. Ground the cabinet to the MGN ground if available. If not available, ground the cabinet to the strand.

## 27.6 Ground-Mounted Cabinets

The site chosen for the installation must conform to all local codes, and required permits must be obtained prior to the start of installation. The location of the cabinet must be accessible and provide adequate parking for worker and vehicle safety. The installed cabinet must not create a visual or physical obstruction to vehicular or pedestrian traffic. Ensure that there is sufficient space on all sides to facilitate cabinet installation. Depending on landscape requirements, the top surface of the concrete pad may be located

flush to 3 inches above the surrounding grade.

Place a ground rod within the pole-mounted frame opening at the indicated point. The top of the rod should be located 1 to 2 inches below the top of the finished concrete pad. Connect a No. 6 AWG grounding wire to allow it to be routed into the cabinet as the cabinet is being mounted on the pad.

Use the following procedures to mount the cabinet on the concrete pad:

1. Use appropriate lifting equipment when moving or installing the cabinet. Do not stand under the cabinet as it is being lifted into position for installation.
2. Using appropriate lifting equipment, attach the line to the cabinet's lifting eyes and hold the cabinet in position for mounting over the concrete pad.
3. Carefully route the attached OSP feeder and distribution cables into the conduit and pull each cable through to the splice enclosure.
4. Insert the ground wire through one of the unused grommet holes at the bottom of the cabinet and pull through several feet of slack.
5. Lower the cabinet onto the pad, securing the cabinet to the anchors/threaded rods designed to hold the cabinet to the pad.
6. Attach the No. 6 AWG ground wire to the cabinet's grounding lug.
7. The lifting eyes may be left in place or removed from the cabinet.

## **27.7 Factory Installed Termination System (FITS)**

### **27.7.1 General Considerations**

A FITS is an assembly of customized plant products that are pre-designed and manufactured to fit a prescribed area of outside plant. It is shipped from a supplier's location ready for placement with pre-installed splices, connections and terminals. The product generally comes with 4, 6, or 12 fiber port terminals pre-terminated on a cable reel.

This product is used in areas that have been designed and carefully measured for custom fit by an outside plant engineer. It is an alternative to traditional cable installation and may be particularly appropriate in new developments or where there is minimal interference from older installed facilities, i.e., "Greenfields" applications.

### **27.7.2 Aerial FITS Plant**

Fiber Distribution Areas (FDAs) are fed from a Fiber Distribution Hub (FDH) located 1,500 to 2,000 feet in any one direction from the customer. A

general FIT deployment for such an area would have the following characteristics:

- The distance from an FDH to the customer's end loop should not exceed 2,000 feet.
- An average of 10 to 15 terminals located at ~125-foot intervals.
- Approximately 225 feet of cable run to the FDH.
- Slack loops will be added at specific points along the route, at the option of the OSP Engineer.

This extra cable slack may be required by the engineer at prescribed locations for future growth considerations, to assist in re-configuration of cables, and for easier access to the cable components after installation. Care should be taken as to where and how these slack conditions are left and secured on the pole or ground, or inside handholes or other closures.

Any cable loops need to comply with the cable bend criteria:

- Optical fiber cable under no tensile load should not be bent to a radius less than 10 times its own diameter.
- Fiber cable under load should not be bent to less than 20 times its cable diameter.

It should be recognized that loops hung from aerial strand and pole attachments can be under compressive loads at the attachment points (cable ties, hooks, etc.) as well as experience tensile stress (at outer surface) and compressive stress (inside of loop) from being formed into the slack loop.

Placing the FITS from the last pole on the run towards the FDH is the most effective procedure, since this allows for some additional flexibility in adjusting terminals to pole locations.

FITS is best suited for unobstructed cable runs. It is strongly recommended that some time is given to removing obstacles that might cause problems during installation such as trees, drops, cables, and other plant or environmental conditions.

### 27.7.3 Buried FITS

The FITS system can also be applied in buried plant design if the soil conditions and route layout permits. Difficulties can arise because of discrepancies between the real-world trench layout and the as-manufactured and pre-designed cable plus splice/terminal configuration. Uneven or rough terrain, and changes to the builder's plans, can cause significant redesign and changes from the pre-designed cable segment lengths and precise locality of the terminals. The equipment operator must be informed when a FITS application has been designed to ensure that the design is adhered to whenever possible.

## 27.8 Premises-Powered Broadband Communications Systems

A new Article 840 was developed for the 2014 Edition of the NEC to cover premises- powered, optical fiber-based broadband communications systems that provide a combination of voice, video, data, and interactive services through an Optical Network Terminal (ONT) located inside the customer premises. The ONT is back fed with power from the customer. A typical system configuration consists of an optical Fiber cable To The Premises (FTTP) supplying a broadband signal to an ONT that converts the broadband optical signal into component electrical signals such as traditional telephone, video, high-speed Internet, and interactive services.

Powering of the ONT is typically accomplished through an ONT Power Supply Unit (OPSU) and Battery Backup Unit (BBU) that derives their power input from the available AC at the premises. The optical fiber cable is usually all dielectric (i.e., non- conductive), although some armored cables may have metallic shields or metallic support strands that are conductive.

The creation of a separate Article 840, rather than inserting requirements within a number of existing articles, enhanced the usability of the NEC by placing all requirements for premises-powered broadband communications systems in a single location. This arrangement served both to highlight and to inform installers as to the similarity to, and differences from, the grounding requirements in Articles 800 (traditional telephony systems), 820 (traditional CATV systems) and 830 (network powered communications systems).

The ONT in these systems provides a single point at which the power supply, CATV, telephony and data (Internet) services are co-located, and it is imperative that the grounding at this point is not inadvertently disconnected. For example, unplugging the ONT for maintenance, replacement or repair should not disconnect the grounding connection provided for safety. For a review of grounding and bonding requirements for communications drop plant, see [Chapter 25, “Bonding and Grounding - Drop Cables and Service Wires,”](#) including the applicable grounding procedures for tracer wires, and metallic shields of the optical fiber cable serving the customer premises.

For the 2017 Edition of the NEC, Article 840 was expanded to include all premises- powered network architectures, including metallic twisted pair and coaxial cable systems supporting systems such as Power-over-Ethernet (PoE). However, all the requirements for FTTP networks remain the same in the new Article 840 of the 2017 and 2023 NEC.



## 28 Symbols for Grid and Mapping Diagrams

### 28.1 General

This chapter provides a list of general use graphic symbols for the designation of electrical, electronic, and pole line devices for layout drawings of Cable Television (CATV) and optical fiber systems.

The purpose of this chapter is to provide default graphic symbols that are easy to draw, easy to interpret, and agree with similar standards used within the electrical and electronic industry. In particular, the basic considerations of American Standard Y32.2, CSA Z99, and International Electrotechnical Commission (IEC) Publication 117 have been followed. It is not the objective of this chapter to be comprehensive in all possible symbols for all possible circumstances.

The symbols for devices do not indicate a certain type of model number of any manufacturer; they represent the function of a device in a system. The symbols permit the easy addition of model or type numbers within or near their outline. If model or type designations are used, they shall be explained on the legend sheet for the drawing on which the symbols appear.

Because of the necessary crowding of symbols on CATV and fiber mapping and grid diagrams, some symbols must be structured differently than those used in electrical and electronic circuit diagrams.

This chapter does not use reference designation and class designation letters.

The IEC indicates a symbol recognized by the International Electrotechnical Commission.

The broken line ( - - - - - ) indicates where line connection to a symbol is made and is not a part of the symbol.

#### 28.1.1 Commentary

The symbols and systematic approach in the Chapter 28 arose from needs to have information on blueprints and network plats presented in a uniform consistent manner across many companies and geographic areas.

Therefore, the information provided here is of use for reading old network maps that are often referred to as plat maps. Plat maps and network plot maps are used to show the communications and other utilities that exists within a given area. The plat can show where structures, setback lines, easements, and Rights-of-way exist on properties. The communications network plat will also contain information on:

- cable types, sizes, and pair counts,
- the location of poles, cabinets and other supporting structures,

- line segments – aerial, underground or buried spans,
- equipment identifications – power supplies, splices, etc... ,
- property lines for served customers, with
- additional notes on special circumstances or conditions that may be present.

Traditionally these large (12x17 inch) detailed plat maps were in bound into a binder for access by the design engineer to plan out additional plant installation or new attachments.

The modern design engineering and field engineer now has access to powerful software and remote access to maps and databases to make their work more efficient. The versatility permitted by modern software applications for digital design and engineering tools provides the capability of detailed information being incorporated in pop-up screens, hyper-links and other computer aided design (CAD) features.

## 28.2 Drafting Practices Applicable to Graphic Symbols

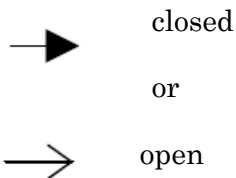
The orientation of a symbol on a drawing, including a mirror image presentation, does not alter the meaning of the symbol.

The width of a line does not affect the meaning of a symbol. In specific cases, a wider line may be used for emphasis.

The symbols shown in this section are in their correct relative size. This relationship shall be maintained as near as possible on any particular drawing regardless of the size of the symbol used.

A symbol may be drawn to any proportional size that suits a particular drawing, depending on the reduction or enlargement anticipated. If it is essential for contrast, some symbols may be drawn relatively smaller than the other symbols or a drawing. It is recommended that only two sizes be used on any one drawing.

The arrowhead of a symbol may be



unless otherwise noted in this section.

For simplification or clarification of a drawing, parts of a symbol for devices, such as amplifiers, may be separated. If this is done, suitable designations to show proper correlation of the parts shall be provided.

## 28.3 Aerial Plant

### 28.3.1 Poles

Unless otherwise specified, poles are wooden. For poles of other material, the following letters should be shown within or adjacent to the pole symbol.

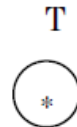
|   |          |
|---|----------|
| M | Metallic |
| C | Concrete |

Unless otherwise specified on drawings or referenced documents, pole usage and ownership are the same. For modification, the following letters should be shown adjacent to the pole symbol.

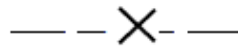
|   |                            |
|---|----------------------------|
| T | Telephone (Communications) |
| J | Joint                      |
| P | Power (Electric)           |

The asterisk only denotes where the symbol shall be and is not part of the symbol.

Always denote pole ownership and conditions not covered by the above information with the appropriate designation within or adjacent to the circle.



Power-Company (Non-Telecom) Owned Pole



Telecom-Owned Pole




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## Joint Usage, Power, and Telecom Pole



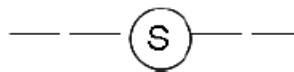
## With Power Transformer



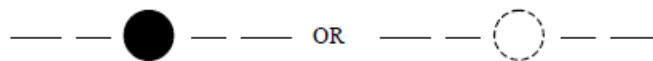
## CATV Pole



## Subscriber Pole



## Proposed Pole

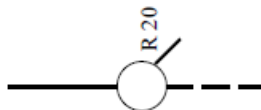


**Riser Pole** – The number indicates the vertical distance from the aerial connection to ground level.

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On other supporting type structures, show the approximate structure outline or a portion thereof.



Make-Ready or Pole Line Preparation Requirements – Arrangement of existing equipment on the pole must be altered for CATV installation.



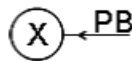
### 28.3.2 Pole Line Support Elements

Poles in the following symbols are shown as joint power and communications (telephone) poles because this occurs most frequently.

Push Brace – Support pole is smaller symbol. It should be drawn in its actual supporting position relative to the pole it is bracing.



or



Extension Arm



### 28.3.3 Cable Support Elements Stranded or Solid Messenger Items With Poles Shown

Tensioned Messenger Wire



Slack Span, Messenger Wire



Tensioned Messenger Wire without Cable (Overhead Guy)



### 28.3.4 Anchoring and Guying With Poles Shown

Letter and symbol abbreviations are often used to provide more detail.

A Anchor - Telecom-Company Owned



Anchor - Foreign (Non-Telecom) Owned



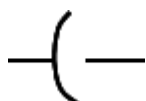
Anchor - Joint Owned

SWP Swamp Anchor

RB Rock Bolt Anchor



Head Use Guy

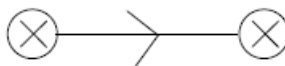


Insulated Guy

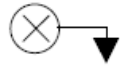
JU Joint-Use Guy

TRG Tree Guy

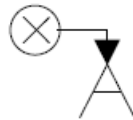
Pole-to-Pole Guy (arrow points to the down direction of the guy)



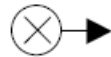
Sidewalk Down Guy – Without Anchor



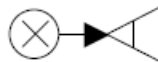
Sidewalk Down Guy – With Anchor



Down Guy – Without Anchor



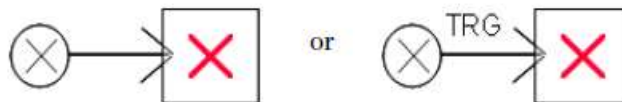
Down Guy – With Anchor



Strut



Tree Guy and Anchor



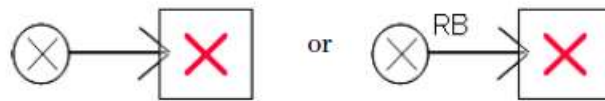
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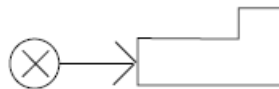
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## Rock Guy and Anchor



## Building Guy and Anchor

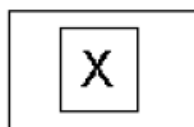


### 28.3.5 Cross Connects

Cross Connect – Pole Mounted



Cross Connect – Pad Mounted

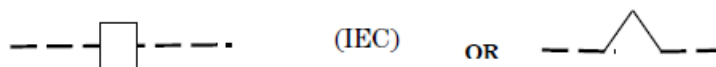


### 28.4 Underground and Buried

Underground Routing – Direct Buried



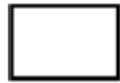
Pedestal – Symbol on Underground Routing Symbol, not Cable Symbol



Manhole – Symbol on Underground Routing Symbol, not Cable Symbol



With the shape of the manhole reflected in the shape of the open symbol.



Rectangular Manhole



L-Shaped Manhole



V-Shaped Manhole



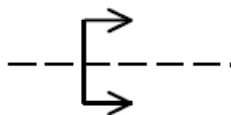
Handhole - Pull Box

or

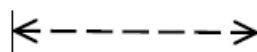


Handhole (Vault) shown with cable

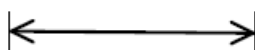
## Underground Routing – Duct Line



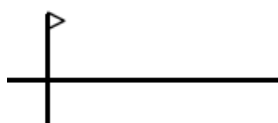
- Direct Burial of Cable



- Burial of Cable in Conduit



## Underground Distribution System Marker



## 28.5 Terminals

Generic Terminal



Basic Pedestal Closure Terminal



Example symbols for selected variations on pedestal type and content:



Pedestal - Loop thru Unprotected Terminal



Pedestal - Loop thru Protected Terminal



Building Unprotected Terminal



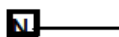
Building Protected Terminal



Pedestal Lock terminal



Sub-Surface Terminal – Enterable



Sub-Surface Terminal – Non Re-enterable

## 28.6 Telecom Metallic Pair Devices

Some examples of device symbols:



Load Coil



Repeater Station Device



Transformer Device



NID Device

## 28.7 Power

Transformer Platform or Pad

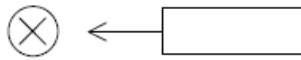


## 28.8 House CATV Drop Designations With Poles Shown

Individual Dwelling – Numeral indicates number of potential house drops at this location.



Multiple Dwelling Units – Numeral indicates number of dwelling units; arrow indicates tap location.



Non-Residential Building (school, church, local organization, etc.)

**Note:** *The asterisk is not part of the symbol.* Always replace the asterisk with the appropriate designation for the type of building or service.



Make-Ready or Pole Line Preparation Requirements – Arrangement of existing equipment on the pole must be altered for CATV installation.



## 28.9 CATV Devices

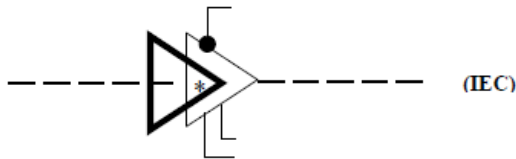
### 28.9.1 Power Devices - Amplifiers

The triangle is pointed in the direction of normal (downstream) distribution.

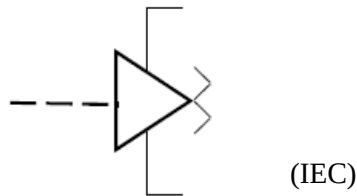
Amplifiers on feeder lines (lines that may accept subscriber taps) should be drawn uniformly smaller than amplifiers on trunk lines. Designation shall be explained on the legend of the drawing or in the referenced document.



Amplifier shown with subscriber distribution. Dot indicates high output feeder line, if applicable.



Bridging amplifier with subscriber distribution on trunk termination.



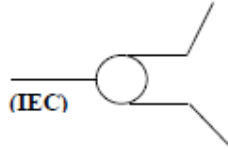
Terminating bridging amplifier with subscriber distribution.



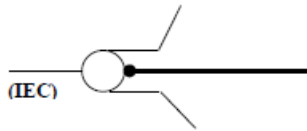


### 28.9.2 Power Devices - Splitters

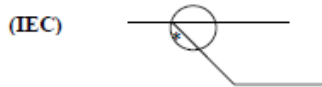
#### 2-Way Splitter



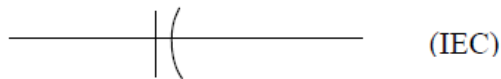
#### 3-Way Splitter – Dot shows high output



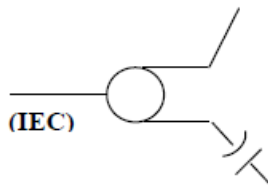
Directional Coupler – Model or value designations to be shown adjacent to the symbol. High loss leg leaves from angular half of symbol. *The asterisk is not part of the symbol.* Replace the asterisk with the model number or performance characteristics (value) within or adjacent to the symbol.



### 28.9.3 Power Devices - AC Power Block



Application: 2-Way Splitter with AC power block.

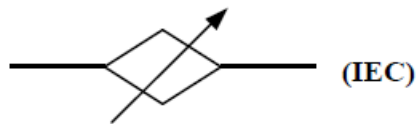


### 28.9.4 Equalizer

Fixed Equalizer



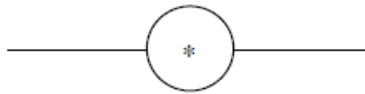
Variable Equalizer



### 28.9.5 Subscriber Taps

Subscriber's Port Blocks AC Power

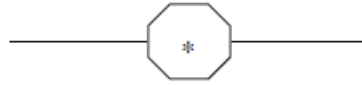
2-Output Directional Tap – *The asterisk is not part of the symbol.* Replace the asterisk with model number or performance characteristic (value) within or adjacent to the symbol.



4-Output Directional Tap – *The asterisk is not part of the symbol.* Replace the asterisk with model number or performance characteristic (value) within or adjacent to the symbol.



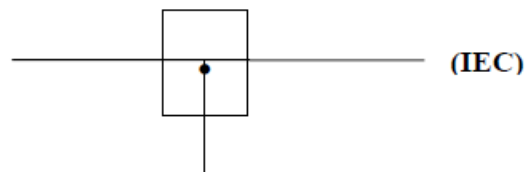
8-Output Directional Tap – *The asterisk is not part of the symbol. Replace the asterisk with model number or performance characteristic (value) within or adjacent to the symbol.*



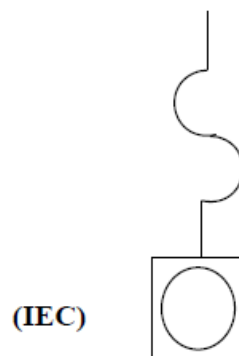
Other Taps – Taps with other numbers of drops and taps other than directional, e.g., pressure, should be designated by modification of these symbols or the listing of new symbols on the legend sheet for each design.

## 28.9.6 Other Powering Devices

Cable AC Power Combiner

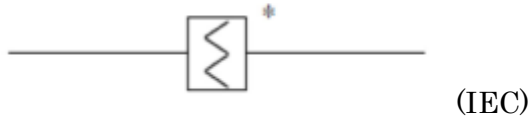


Power Supply

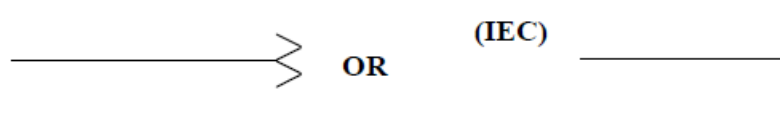


### 28.9.7 Other Devices

Fixed Flat Attenuator – *The asterisk is not part of the symbol.* Replace the asterisk with model number or performance characteristics (value) within or adjacent to the symbol.



Line Termination – AC Power blocking unless otherwise noted.

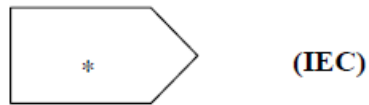


### 28.9.8 Carrier Equipment

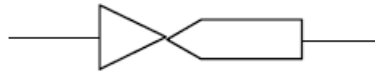
Carrier Control Generator:

[1] The symbol points in the direction of its transmission.

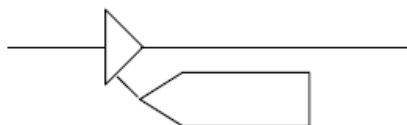
[2] *The asterisk is not part of the symbol.* Replace the asterisk with the appropriate descriptive designation.



Application: External



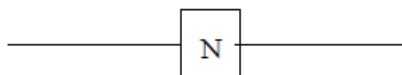
Application: Internal



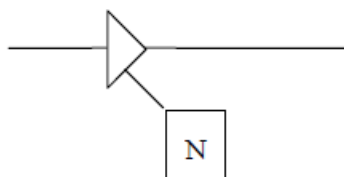
Notch Filter (Narrow Band Stop Filter)



Application: External



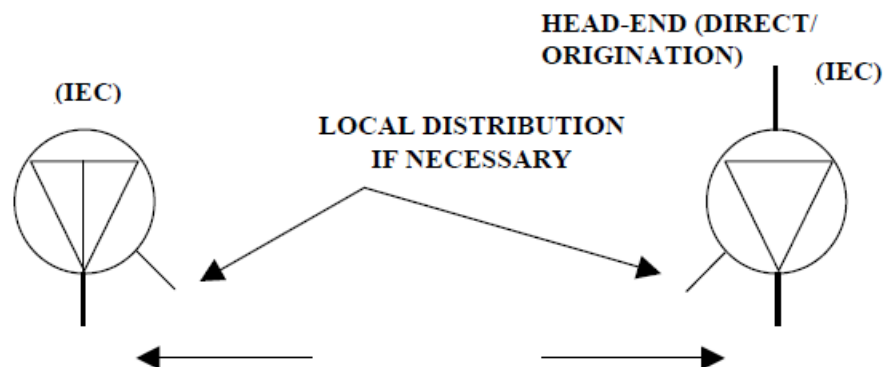
Application: Internal



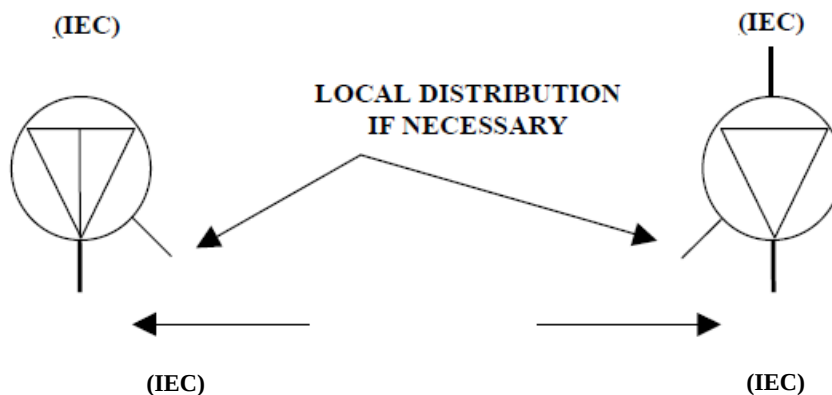
### 28.9.9 Signal Processing Locations (Antenna Site, Head-End, Hub, etc.)

**Note:** The symbol needs to be conspicuously large to represent the size of the facility.

Primary



Secondary



### 28.9.10 Coaxial Cables

**Note:** Specific coaxial cable function, other sizes, or type, must be designed by modification of these symbols or the listings of new symbols on the legend sheet for each design.

0.750 inch Coaxial Cable



0.500 inch Coaxial Cable



0.412 inch Coaxial Cable



## 28.10 Optical Fiber Plant

### Representative Optical Fiber Plant Nodes



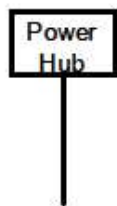
Fiber Remote -  
HDT (Host Digital Terminal) Site



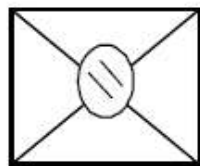
Fiber PON Splitter



Fiber ONU



Fiber Power Hub



Fiber Terminating Equipment



## Appendix A: Clearance and Loading Issues in NESC

### A.1 Clearances

#### A.1.1 Historical 1990 Changes

A major change in the method for specifying clearance rules was introduced in the NESC 1990 Edition, which required clearance values to be specified at the closest approach, as described in [Section 3.1](#).

In previous editions (i.e., NESC 1987 and earlier), the clearance values indicated in tables were basic clearances, applied under specified basic conditions, for example, at a temperature of 60°F (15°C), but subject to limited span lengths, voltage levels, and conductor operating temperatures. (Conditions outside these basic conditions, e.g., relatively long span lengths, high voltages, or high conductor operating temperature, required additional clearance increments.) Actual clearances varied from these values specified at 60°F (15°C) owing to conductor sag changes resulting from the added effects of temperature and ice loading.

Thus, while some clearance values in the NESC 1990 Edition appear to be larger and some smaller than in the NESC 1987 Edition, the net effective clearances for energized conductors and cables were essentially unchanged for most cases.

#### A.1.2 Rule 235H - Clearances Between Communications Lines

The current Rule 235H contains the key spacings of 12 inches at pole and 4 inches in mid span. Over previous code cycles, there is some inconsistency in how the rule is interpreted. The new Rule 235H in 2023 has clarified the situation with :

- Vertical spacing shall be 12 inches minimum at pole
- Vertical spacing should be 4 inches minimum in (across) the span with a note that the spacing can be achieved through the use of spacers.
- The conditions under which the 4-inch separation in the span shall be calculated was better defined as the same operational conditions on each cable and:

Option A = under “anticipated/expected conditions”, which includes both hot summer conditions and cold winter (with ice)

Option B = “at 60°F with no wind and no ice loads”, which reflects the average installation conditions when the spacing is initially set.

Option A is more universal but more difficult to implement and assess since it requires a wider range of engineering calculations.

The 2023 NESC Rule 235H provides flexibility to communications utilities.

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With the space demands for new wireless equipment, mounting antenna and equipment on strand messengers will become more common. Such configurations can result in conflicts and possible abrasion between lines and equipment on adjacent strands. One of the objectives of 235H is to minimize such problems and help avoid damage to lines or service.

### **A.1.3 Wireless Facilities - Rule 235, 238F and Other Related Rules**

As the 4G/5G modern wireless networks are built out to satisfy service demands, the congestion on poles and structures will raise questions on NESC rules, joint-use agreements, licensee contracts and other means to address the need for many antenna sites along with their associated facilities that supply power and back-haul communications for the wireless units.

These clearance and separation discussions will encompass many of the individual rules in Section 23, along with considerations of RF Exposure concerns (Part 4 of NESC) and other parts of the NESC.

In the 2023 Issue of the NESC, wireless clearances and separations were consolidated under new Rule 238F gathering clearances from the old (2017) Rules 235I, 236, 237, 238 and 239. Many other chapters of the *Blue Book* will also apply to the backhaul communications cables (optical fiber or twisted pair cables) and powering circuits that need to serve the antenna facilities.

This consolidation effort will be helpful for wireless network companies, for their designs, as well as for their approval requests with pole owners and other joint users. An IEEE joint-use guide (P2939) summarizes consequences of these 238F clearances and other issues around the attachment approval process.

See Chapter 15 of this *Blue Book* for a full discussion of NESC code and safety concerns for wireless facilities along with information on clearances (Chapter 3) and other related chapters.

### **A.1.4 NESC Clearance Zones and Loading Districts**

The American Society for Civil Engineers' ASCE 7 standard, *Minimum Design Loads for Buildings and Other Structures*, contains ice loading maps and concurrent wind speed for the USA. The ASCE's ice and wind maps are important sources of meteorological information specifically prepared to aid structural design activities.

“District” versus “Zone” – The use of these terms needs to be harmonized between Sections 23 and 25/26 of the NESC. They are used as synonyms in the code, and clarification is desirable to distinguish between clearance zones as used in Section 23, and the loading districts or loading zones that are both used in Section 25/26 along with wind districts/zone usage. The terminology used for these climates and loading areas also needs to be harmonized with the related and referenced ASCE standards to help prevent confusion and

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misapplication of wind and ice loadings between different standards. Different criteria and factors are necessary to match the objective of the calculations – pole loading and design safety factors in Sections 24-26 and maximum expected sag/tension values to help determine maximum final sags for lines to exceed the minimum clearances from ground, other lines and structures.

Sections 24 through 27 of Part 2 of the NESC comprise the strength and loading rules for overhead (aerial) lines. These sections have evolved over an extensive period of time, reflecting various independent changes deemed necessary to maintain the value and credibility of the document. The following discussions points in the SC5 committee (Pole Loading and Strength) meetings of the NESC are expected to be active areas into the next cycle.

#### **“K<sub>z</sub>” factors and Ice Loading Factors**

- Tradition – The “K” factor has been used since 1941 and users are comfortable with it. A 70-year history of reliability under current pole strength design, clearance levels, and sag calculations was acknowledged. The additive constant (“k-factor”) is a misunderstood term that was introduced when a reduction in maximum wind speed (e.g., from 8psf to 4psf) was introduced to better simulate expected weather conditions on pole loadings.
- Practical Implementation – The concern that the safety levels currently in effect not be compromised. Replacing the “K” factor with different ice/wind loadings could result in confusion and errors within current engineering practices and available software systems.
- The k-factor was retained for the 2017 and 2023 code. For communications, the differences are small (5%) in the tension and could be accepted with little concern. The effects are more significant for the electrical utility companies and the effects on power supply conductors and transmission structures. The smaller the wire, the more significant effect on the k-factor. The longer the span, the more significant effect of the k-factor. The administration costs and added confusion may not be worth the minimal safety gains.

Various options were thoroughly discussed in the 2023 code cycle with the option eventually accepted by SC4 and SC5 to retain the additive constant (keep status quo), which continues the current methods and procedures which have proved adequate and accurate. The desire to maintain consistency between the two subcommittees was an important consideration in this decision. Further proposals and revision proposals are anticipated next cycle.

**Construction Grades** – Rule 242 was refined and clarified as to the use of Grade N, and the need for a new Cx grade for crossings was rejected. The much revised version of the Table in the 2023 code is an improvement along

with further modifications and improvements made during the SC5 meeting. All these changes have increased clarity, accuracy and simplicity for the use of the Table 242-1 and were encouraged and supported by your representatives (see Chapter XXX).

The references to Grade N construction in Rules 242 and 263 are appropriate and will be retained in the 2023 NESC. Grade N is useful bottom line construction grade for communications and power utilities, particularly in passages and spans across customer property, as well as in some temporary and emergency situations. The rule details may be updated and rationalized in the next code cycle, but it was important to retain the concept and appropriate references to Grade N.

**60 Foot Pole Exemption** – There was strong support to retain the 60 feet exemption at the moment. There may be some merit to a possible future action to consolidate all 60 feet exemptions into an early part of Section 25 with cross reference to applicable rules. One advantage to such an action would be to help defend the 60 feet exemption position in front of local code and regulatory commissions. Any such change would need to be part of a major re-write to be useful and practical. Such a major re-write would need to include various factors and section revisions with consideration of (a) the possible replacement of the k-factor with different wind/ice load factors, (b) the inclusion of non-linear calculation methods, (c) the 60 foot exemption, and (d) harmonization with references to which ASCE standards should be used.

The 2023 decision to retain the current 60 ft criteria, limiting the application of Rule 250C (extreme wind) and 250D (extreme ice) to tall, non-distribution structures is an appropriate action and corresponding to real world experience during storm events.

**Non-Linear Analysis Options** – There is general support for the introduction and use of the latest calculation approaches and software tools including the non-linear methods to obtain more accurate and precise results. The inclusion of specific code language to introduce such non-linear approaches is not necessarily simple and will require changes in many NESC sections and be a part of a wider effort discussed above.

In 2023 edition, a two-map approach was adopted as being more appropriate with the 100 year MRI loading map for Grade B construction and the 50 year MRI (Mean Return Interval) loading map for Grade C based on recent edition of the ASCE 7 and ASCE 74 standards. The two map approach is slightly inconvenient from a calculation procedure standpoint and may raise create some misunderstandings from a superficial risk perspective, but the two maps are a more accurate representation of comparative wind loads for the different construction grades and applications.

See further discussions on these pole loading and strength concerns in Chapter 13 of this *Blue Book*.

## Appendix B: NESC Code Cycle

### B.1 2023 NESC Code - Overview

The 2023 National Electrical Safety Code® (NESC®) was published in August 2022 and scheduled to be effective on or before February 1, 2023. The effective date is determined by the local legislative and regulatory procedures within the different states of the USA. The release of the NESC was delayed by a year (from 2022 to 2023) because of covid 19 epidemic.

Issue 7 of the *Blue Book* incorporates the relevant changes that have occurred in the latest NESC 2023 that is now available along with NESC construction-related products such as the new NESC Handbook (see: <https://standards.ieee.org/products-programs/nesc/>).

The NESC sets the ground rules for practical safeguarding of persons during the installation, operation, or maintenance of power, telephone, cable TV, and railroad signal systems. Major revisions to the 2023 Edition include:

- (1) the explicit understanding that the Code is intended to primarily address the practical safeguarding of persons,
- (2) the priority of customary (inch-foot-pound) units over metric units,
- (3) new rules providing requirements for photovoltaic generating stations,
- (4) recognition of new battery technologies, applications and hazards,
- (5) relaxing of the grounding intervals for a multigrounded system for underwater or difficult terrain installations, as well as for underground installations with random separation, independent on the difficulty to implement,
- (6) the consideration of antennas as equipment, rather than a “rigid” conductor, for the purposes of specifying clearances,
- (7) the reframing of the requirements for the application of the extreme wind and extreme ice with concurrent wind loadings to emphasize they represent additional loading conditions applicable for tall structures or lines, and
- (8) an additional table available for use as an alternative to performing a detailed arc hazard analysis to determine required clothing.
- (9) Section 14 has been rewritten to recognize new battery technologies, applications, and hazards; new content addresses switchgear and plant batteries, and grid storage batteries.
- (10) The previous rules in Section 19 have been combined into revised Section 17, allowing new Rules 190–195 for photovoltaic generating stations in revised Section 19.
- (11) Part 2 (Overhead Lines) is the most extensive portion of the NESC, and is therefore subject to the most changes between subsequent editions. These changes address clearances and strength and loading

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requirements, in addition to other rules affecting the overhead lines and persons. All the significant changes to Part 2 of the NESC have been discussed in this Blue Book – either in chapters or the Appendices.

(12) For loading requirements, Extreme Wind loading Rule 250C has been reframed to emphasize that it represents an additional loading condition applicable for tall structures or lines, as well as any structures prior to the installation of conductors, rather than suggesting it is a general loading condition from which shorter lines are exempt.

(13) The previous wind map used for both Grade B and Grade C structures is replaced by a 100 year Mean Recurrence Interval (MRI) map for Grade B and a 50 year MRI map for Grade C, in Figure 250-2. A new method is used for calculating the gust response factor for both the structure and the wires, as provided in Table 250-3. The Table 253-1 load factors for Rule 250C are now 1.0, consistent with the use of the separate wind maps for Grade B and Grade C construction. Appendix C provides examples illustrating the use of the formulas for determining the corresponding wind pressure.

(14) In Part 3 (Underground Lines), a new Note in Rule 313A2 indicates inspections may be performed when performing other duties, similar to the existing Note in Rule 214A2 for overhead lines.

(15) There is now a burial depth requirement (Rule 344A7) for communications cables with “special supply circuits” if the voltage and power exceed communication levels.

(16) The required intervals for bonding or grounding in Rule 354 (direct-buried cables, random separation) for certain applications have been relaxed, analogous to that of Rule 096C.

(17) In Part 4 (Work Rules), Table 410-1 and Table 410-3 have been revised and new Table 410-4 provides arc ratings for clothing systems for medium voltage (1 kV to 36 kV) for enclosed live-front equipment.

(18) A specific radio-frequency safety program is now required for exposed employees.

(19) Rule 420G for batteries has been extensively revised and expanded to cover other battery types and applications, including stationary batteries and energy storage systems.

(20) In Section 44 (Additional Rules for Supply Employees), neutrals, messengers, and guys are added to the list of items to be guarded or insulated, and sources of backfeed, such as from distributed energy resources, must be considered when de-energizing lines.



## B.2 NESC Code Cycle Schedules

After the official publication date of the NESC, the new code cycle begins with the following dates associated with the NESC 2028 Edition code cycle. See [Table B-1](#).

**Table B-1 NESC Dates of Interest**

|                     |                                                                                                                                                                   |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15 May 2024         | Final date to receive Change Proposals (CPs) to the published 2023 NESC Edition                                                                                   |
| August–October 2024 | NESC Subcommittees meet and consider CPs and prepare recommendations                                                                                              |
| 1 July 2025         | Preprint of 2028 NESC with recommended CPs incorporated is published for distribution to subcommittee members and other interested parties (public)               |
| 24 March 2026       | Final date to submit comments on the submitted CPs and the published Preprint of the 2028 Edition                                                                 |
| August–October 2026 | Period for NESC subcommittees and working groups to reconsider all recommendations and comments received --> a final report is prepared of 2028 Edition           |
| 15 January 2027     | Proposed revision of the NESC submitted to main NESC committee for letter ballot and to American National Standards Institute (ANSI) for concurrent public review |
| 14 May 2027         | NESC committee-approved revisions of the NESC is submitted to ANSI for recognition as an ANSI standard                                                            |
| 1 August 2027       | Publication of the NESC 2028 Edition for implementation on or before 1st February 2028                                                                            |

## B.3 NESC Working Groups and Possible Future Issues

Informal and formal Working Groups (WGs) are formed under the auspices of the various sub-committees of the NESC to investigate various issues and propose code changes that may need to occur for the 2023 Edition of the NESC as TIA changes or under the Fast Track mode process or in the next code cycle for the 2028 NESC. Some of the issues of particular interest to the telecommunications industry that are being explored are listed below for reference.

- A. **Rule 215C - *Grounding of circuits, supporting structures, and equipment*** – The particular Rule 215C (“Non-Current Carrying Parts”) concerns guys, anchors and insulators. The concerns raised and

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the 2017 changes were designed to clarify this rather complicated rule with the major technical issues around:

- 8 ft vs. 10 ft. vs. 14 ft as the minimum ground clearance for bottom of insulators – These insulators help protect communications workers. The current value of 8 feet is sufficient for safety, and Ericsson - NIS will continue to support the value of 8 feet as a minimum value in 215. However, there are related ground clearances over driveways that may benefit from increases because of the 9-11 feet high RV and delivery vehicles are more and more common. Future code proposals are expected to support an increase to possibly 10 feet minimum. These issues are discussed in Chapter 3 and 9 of this *Blue Book* with the minimum 8 feet of clearance used in the figures in that chapter.
- A minimum height in any of these rules does not prohibit the insulator from being placed higher and even above the communications line height to help prevent transfer of supply voltage/current onto communications lines in case of a broken or slack anchor guy.
- The 2023 version Rule 215C covers the situations where there are multiple messengers on the same structure. These “multiple messengers on the same structure” are designed primarily for communications cable messengers which would be on joint-use situations. This sub-section emphasizes that these communications messengers need to be “*bonded together at intervals specified in Rule 092C1*”. The terminology “bonded together” is a little different from being grounded or effectively grounded, which is more what 092C1 is about. This subsection provides protection for the communications worker against energy transfer to the communications strand caused by a slack or broken guy contacting a strand in the communications space.

**B. Rule 232 - Minimum Heights Above driveways** – The discussion on Rule 215C and how high a person on the ground can reach raised questions about the reference 8 foot height and if it should be raised to 9 foot or 10 feet or higher that would have consequences for other rules. It is anticipated that over the next code cycles, new change proposals may increase minimum heights above the ground. One such related rules is that for the safe height over driveways.

- Although the 8-foot gap to make structures not readily climbable is realistic and practical, the allowable reduction in clearances (via footnotes 7/8 of Table 232-1) over residential driveways to as low as 10 and 10.5 ft is no longer practical given the larger RV vehicles (usually 8.5 to 9.5 ft in height) and especially delivery vehicles (12 feet) that are currently in use. It may be anticipated that delivery vehicles, transit vans and recreational vehicles up to at least 10 to 11 feet in height will be encountered in most driveways. Therefore, assuming the 8 feet maximum vehicle height is no longer a useful

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value, the minimum ground clearance over a driveway for a communication line (drop) should possibly be 12 feet (communications) and 13.5 to 14 feet (power).

- The NESC is not a retroactive code (as outlined in Rule 013). However, it is possible, even with the present allowances, that millions of existing service drops would be considered too low if the original rationale for the reduced clearance (i.e., tall vehicles are not expected) is no longer valid. In such cases, there may be a litigation risk if the affected service drops are not raised appropriately (e.g., 15.5 feet) - with commensurate lifting of the power service drops and possible addition of masts on houses and need for taller poles to obtain the increased ground clearances.

C. **Rule 235H - *Clearance Between Communications Lines*** – see Appendix A (Section A.1.2) and Chapter 3 of the Blue Book.

D. **Arc Flash Hazards - NESC Part 4 (Work Rules) and Rule 410A3** are harmonized with the OSHA 1910.269 regulations and ASTM test methods for protective gloves and equipment. Other codes such as NFPA 70E on arc flash concerns during electrical work are equally relevant and currently harmonized with OSHA in general. The equivalent communications OSHA reference is 1910.268. These arc flash risk and protection concerns are primarily issues for power supply companies and electric workers because arc flash events are normally associated with voltages greater than 200 volts and high amperage systems.

In 2023 NESC, the arc flash tables of Rule 410A3 were updated with latest laboratory tests with short circuiting electrical panels. The NESC is particularly fortunate to have the real-world test values from full-scale arc tests on deliberate faults with fully configured equipment as the basis of the default table entries to determine PPE levels required. These are not simulated calculations based on software but calorimeter measurements from controlled laboratory tests.

The Co-ops and small supply utilities are the more likely users of these conservative PPE and risk assessment values (Tables 410-1, 410-2, 410-3) if they do not have the in-house staff and/or engineering capability to perform the quantitative calculations for arc-flash exposures

E. **Powering Circuits for Communications Equipment** - A working group (WG 4.8) was created by subcommittee 4 to investigate new powering architectures of Fault Managed Power Systems (FMPS) primarily designed for communications antennas. Although there were no technical changes to rules 224B and 344 made this cycle (some formatting was revised), it was recognized that various new powering architectures are required to match the expansion demands of 5G wireless antennas and their associated equipment. A SC4 working group 4.8 has reviewed the current technologies for communications facilities and prepared revisions to Rules 224, 344, and definitions that

are currently under consideration for Fast Track revisions to the 2023 NESC code.

F. The subcommittee 3 (SC3) of the NESC created a large amount of new code to distinguish between power generation stations, substations and distributed power installation (solar farms, energy storage facilities, etc..). No issues are anticipated for the telecommunications industry that need to serve these power facilities since in other parts of the code it is acknowledged that IEEE standards such as the following are best practices for avoiding functional performance issues at these sites -

- IEEE Std 487™-2015, IEEE Standard for the Electrical Protection of Wire-Line Communications Facilities Serving Electric Supply Locations—General Considerations.
- IEEE Std 487.2™-2013, IEEE Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations through the Use of Optical Fiber Systems.
- IEEE Std 487.3™-2014, IEEE Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Hybrid Facilities.
- IEEE Std 1590™-2003, IEEE Recommended Practice for the Electric Protection of Optical Fiber Communication Facilities Serving, or Connected to, Electrical Supply Locations. (Superseded - replaced with IEEE 487.2 and 487.3 - see below)
- IEEE Std 776-2018, IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines.
- IEEE Std 1137-2018, IEEE Recommended Practice for the Implementation of Inductive Coordination Mitigation Techniques and Applications..

## Appendix C: Network Resiliency, Plant Reliability and Power Interdependence of Communications Systems

The NESC is primarily a **safety code** and the focus of the guidance in the Blue Book is on industry best design and construction practices. If a user fully complies with the NESC rules they also gain increased reliability and improved resilience for their network. Meeting, or more usually exceeding, the NESC criteria of minimum clearances, separations, strength, best operational practices provides additional benefits to longevity and reliability of the network components and systems. Overlaying the criteria of the minimum NESC rules with additional design/engineering choices will provide a network with high reliability, maintain service under all conditions, and provide a highly resilient network.

The general catchall proviso found in NESC General Rule 012C that we should follow “....*accepted good industry practices for the given local conditions...*” provides general guidance that would include following various practices such as -

- Applying best methods and practices (M&Ps) including industry defined emergency response and contingency planning which for telecommunications would include meeting related NRSC, CISRIC and FCC guidelines.
- Using quality products that meet product specifications designed around high reliability of components
- Adding internal company-defined safety tolerances and factors to use larger clearances, separations, strength safety factors,

Increased reliability through additional safety factors and high quality products will reduce the number of failures under extraordinary circumstances (large hurricanes, earthquakes, impact by flying debris, and other events outside normal expectations).

The interdependence between power supply networks and communications system plays a significant role in securing both utility networks for the benefit of the customers and continued availability services they provide. Many communications practices design to be resilient under power outage events such as duplicate diverse routes, backup battery sources and other design and practice features are pertinent to communications but may not have exact equivalents in electrical power systems. Section C.2 explores the inter-relationship and interdependences between the communications and power utility networks.

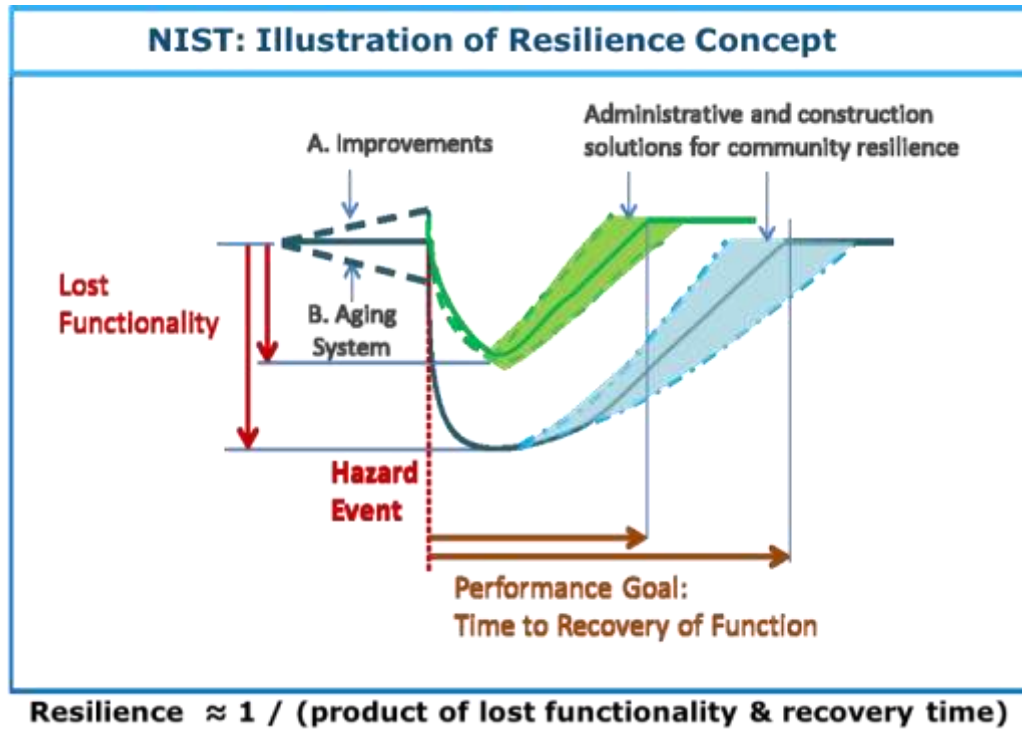
## C.1 Resiliency and Reliability

**Reliability** and **Resilience** are concepts that relate more properly to a system or network and not necessarily to individual network components such as single poles or conductors.

Reliability refers to the ability of the bulk power distribution or communications and systems to deliver services (electricity or communications) to customers during normal “blue sky” operation. Resiliency refers to the ability of the distribution system to absorb operational or environmental stresses without experiencing a sustained outage.

A more resilient network is one that is better able to sustain and recover from adverse events like severe weather – a more reliable system is one with fewer and shorter service interruptions.

An illustration from NIST (National Institute of Standards and Technology) of the resilience concept is shown below with the possible positive consequences of plant improvements, increased component reliability, and more resilient or robust construction design/engineering choices that can shorten service recovery times. The aging of networks can often proceed with minimal impact to service quality or availability until a specific hazard event reveals weak points in the network and leads to large or long service outages.

**Figure C-1 – Resiliency Concept**

Equally important for recovery time can be administrative operational procedures by utilities such as having recovery teams and equipment positioned wisely or having an inventory of sufficient supplies (fuel, replacement components and backup equipment) readily available. Other important factors are less controllable or predictable such as community resilience that needs to be built on customer communication and education to manage the service expectations during major weather or other emergencies. The perceived impact of service disruptions can be significantly reduced when the customers are prepared with their own plans to alleviate the outage – e.g., having whole house generators, portable backup generators, and/or several communications connections (wireline, wireless and satellite connections).

Simple single solutions are not often the most effective or efficient means to increase resilience or reliability. For example, simply using larger stronger poles does not guarantee less failures during wind storms or hurricanes. Widespread experiences confirm building stronger to resist extreme winds does not significantly improve survival rate since during such extreme conditions, healthy (stronger) distribution poles can typically fail owing to falling branches or flying debris. These impact forces from flying objects or debris can be much greater than the design specification forces used for poles to merely withstand the direct effects of the wind. In contrast, facilities supported on taller (e.g., transmission towers) structures may escape the effects of falling branches or flying debris

Therefore, one should avoid across-the-board solutions of using high class (stronger) poles partly because it may not appropriately address the threat, but also because the greater cost of the pole (capital cost of pole and installation cost) may divert resources from other appropriate or beneficial solutions (pole line inspection and maintenance, or regular vegetation management). If a strategy of relying on larger, stronger poles for reliability is followed, then delays in restoration may occur because of non-availability poles of adequate size or delayed availability of appropriate non-wood poles.

Multi-pronged strategies will be the most effective ones which can include:

- Targeted (limited) hardening only of certain critical sites to minimize the effect of single points of failure
- Maintain a frequency of pole inspections and maintenance commensurate with the geographic area (e.g., wood decay zone, wind district) and age/history of the pole.
- Vegetation management to limit the damage from fallen branches, flying debris or an older tree falling across lines or into structures
- Disaster planning with inventory and distributed supplies across the operational territory of the utility.

One contribution of such strategies is compliance with the NESC and other safety standards. For example, following the NESC rules listed below will contribute to the resiliency and reliability of networks – either explicitly or though collateral effects to the network.

**Table C-1 NESC Rules Related to Resiliency and Reliability**

| Rule Number | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 012C        | <p>The general catchall proviso that we should follow “....accepted good industry practices for the given local conditions...” provides a very general guidance that would include following various practices such as:</p> <ul style="list-style-type: none"> <li>• Applying good M&amp;Ps (best practices) including industry defined emergency response and contingency planning which for telecom this would include meeting NRSC, CISRIC and FCC guidelines.</li> <li>• Using good quality products that meet product specifications designed around high reliability of components</li> <li>• Adding company-defined safety tolerances and safety factors to use larger clearances, separations, strength safety factors,</li> <li>• Increased reliability through additional safety factors and high quality products will reduce the number of failures under extraordinary circumstances (hurricanes, earthquakes, impact by flying debris, etc... )</li> </ul> |

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| Rule Number               | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 013<br>and<br>014         | <p>These Rules cover replacing, maintenance or repair of structures as well as permitted practices under emergency or temporary conditions. These rules help to increase speed of recovery after a disaster or emergency event – allows flexibility in repair and permits service to be re-established safely and quickly with full restoration to current applicable code postponed until later.</p> <p>The ability to use Grade N for these emergency restorations also permits means to safely minimize the restoration time which will improve any measure of resiliency.</p>                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Section 2<br>References   | The references in this Section to various design specification, functional requirements documents, IEEE, and UL standards all help to ensure highly reliable and quality products are used in networks that reduce failure rates of components under normal, extreme and unexpected environments and events.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Section 9<br>Rules        | <p>The grounding rules provide</p> <ul style="list-style-type: none"> <li>• Safety = bonding and grounding to safely dissipate foreign or fault currents without loss of services</li> <li>• Bonding between telecom and power help ensure that induction problems do not create or transfer or propagate problems between lines (telecom and power) networks.</li> <li>• De facto design criteria for joint use poles (Rule 097), and the pole lines (e.g., 4 grounds in every mile). Such unity of network grounding/bonding objectives helps workers from different regions and companies quickly restore service because they are familiar with general grounding &amp; bonding configurations.</li> <li>• Help to increase reliability by reducing galvanic corrosion</li> <li>• Resilience increased by</li> <li>• Safely dissipating energy from fault, lightning and power crosses</li> <li>• Breakers designed to dissipate energy to earth and then reset and continue service</li> </ul> |
| 092                       | Solidly grounded fences provide security and control for substations in particular to help prevent a single failure from propagating along the lines to other substations, to customers, or to other nearby facilities.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Section 12                | General uniformity of intent and objectives for inspection, maintenance and testing of substations permits helps workers from different regions and companies quickly restore service because they are familiar with general grounding & bonding configurations and practices of the NESC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 201<br>Scope of<br>Part 2 | <p>“...Part 2 of the Code covers supply and communications and equipment in overhead lines. It covers the associated structural arrangements....”</p> <p>The above scope statement implies there are several rules that have consequences and set de facto minimums for design decisions.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 214                       | Rule 214 requires that a company shall have an inspection, test, monitor and repair program for its plant and will through such a program help mitigate failures and prevent them from occurring thus increasing the reliability of facilities and increasing resiliency by preventing failures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

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| Rule Number                  | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 215                          | <p>All the parts of Rule 215 pertaining to guys, insulators and grounding are designed to help prevent contact with public and short circuits with adjacent plant (supply or communications) in the event of a broken or slack guy. Preventing such incidents will help protect people (safety) and help ensure supply and communications service continue even under conditions where guy is broken which equates continuance of service with resiliency.</p> <p>The selection of specific insulators in Section 27 with specified ratings as per IEEE C29 and factory strengths are minimum functional design rules that help ensure high reliability of components.</p> |
| 217                          | <p>These general rules all have to do with mechanical protection of structures and security to stop climbing or other inappropriate activities around structures (towers).</p> <p>Apart from safety of people (public and workers), the consequences will be to make these structures better able to resist damage from accidents and activities in their vicinity → making them more reliable and robust and resilient.</p>                                                                                                                                                                                                                                               |
| 218<br>Vegetation Management | <p>These vegetation management rules cover the mechanical protection of structures from trees, branches and vegetation. Vegetation properly managed will help prevent collateral damage to facilities and service (i.e., increased resilience) from brush fires, wind blow damage to trees, flying branches – if vegetation is well separated from aerial plant it will be less likely to interfere with lines, equipment and service.</p>                                                                                                                                                                                                                                 |
| 220<br>Preferred Levels      | <p>Aligning with the preferred levels will help separate power and telecom and create less physical and electrical interference. Services will be more resilient to events since a power outage event/failure associated with supply lines or equipment will be less likely to affect adjacent telecom lines and service. Less crossing of lines will lead to less interference and less damage.</p> <p>Similar configurations across the country will help decrease time-to-repair since emergency workers from other companies and geographies will find plant in similar places on poles and structures.</p>                                                            |
| 223 and 224                  | <p>Communications protective elements noted in these NESC rules couple with product functional requirements for surge resistance, EMI immunity and other EMC protection tests to help ensure telecom equipment is resilient under power surges, lightning surges and other possible events. The lines and equipment will experience the stress and respond by shunting energy to earth and re-setting the service.</p>                                                                                                                                                                                                                                                     |
| Section 23<br>Clearances     | <p>The minimum clearances of this section (particularly Rules 235, 238, and 239) help ensure that a fault in one power circuit or one telecom circuit does not negatively affect another service on a different power circuit (distribution, transmission or drop) or communications circuit (CATV, telephony, wireless).</p>                                                                                                                                                                                                                                                                                                                                              |



| Rule Number                                | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 236<br>Climbing Space<br>237 Working Space | Adequate climbing space, boundaries, and clearances helps avoid incidental contact (safety) that could also create short circuits, power crosses that would disrupt service (reliability and resilience)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 241D and 243A4                             | Avoidance of structure conflicts helps with resilience and reliability by avoiding collateral damage to adjacent or nearby facilities (power, communications, railroad, other items...). Avoiding contact with adjacent facilities and structures will make restoration easier and faster.                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 242<br>Construction Grade                  | The use of higher construction grade with higher safety factors for joint structures and structures near specific items (e.g., railroads) will make these facilities and services more reliable and resilient .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Section 25<br>Section 26                   | Strength and loading factors are de facto minimum design criteria to increase reliability under adverse and extreme conditions which in turn will increase resilience (see discussion in Chapter 13) .<br>These NESC sections define minimum safety factors for inclusion in the design process which may be further supplemented by the engineering departments of a utility for their own risk management reasons.                                                                                                                                                                                                                                                                                                               |
| 261H                                       | Design tensions for conductors and effects of wind → de facto minimum design criteria → this rule coupled with the clearance between conductors (Rule 235) helps make plant resilient under high winds and extreme conditions. Coupled with the strength/loading criteria for the structures (rules in NESC Sections 25 and 26) makes it more resilient since the structure will be more reliable and not likely to fail under not only adverse conditions but also under extreme wind conditions.                                                                                                                                                                                                                                 |
| Section 27                                 | Design parameters and product specifications used to attain quality insulators with high reliability.... Couple this with proper placement of these insulators from Rules 215 and Section 9 then one achieves a resilient facility that can resist extreme conditions and maintain service even if one component (e.g., guy strand wire) fails.                                                                                                                                                                                                                                                                                                                                                                                    |
| 320A6<br>351A6                             | <i>“Conduit installed under water shall be routed, installed or both so that it will be protected from erosion by tidal action or currents. The conduit should not be located where ships normally anchor..”</i><br>These rules provide a series of intents and objectives with the actual design choices left to the designer and engineer that could include burial of cable/conduit under the river/lake bed or additional physical protection for cable/conduit, more robust cable designs to make cables more mechanical robust, warning signs on shore, etc...<br>There are various options that can be employed – Rule 320A6 and similar objective rules are guidelines for the engineer to consider these perils and adopt |

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| Rule Number          | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | certain design/engineering choices to address the danger and maintain service (i.e., be a resilient design).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 323                  | Manholes and vaults rules also contain similar design guidance language – “... <i>designed to sustain all expected loads...</i> ”<br>These general NESC rules rely on product functional performance requirements to obtain reliable quality products to meet the application and environment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 330<br>332<br>350    | These supply and communications cables rules contain explicit reference to product specifications and industry standards that is intended to help attain high quality cable products for this outside plant and thereby have more reliable cable products that are more resilient under adverse and extreme conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 351<br>352           | Location and routing – these choices to “... <i>be subject to the least disturbance practical...</i> ” lead the designer and engineer to make choices to help meet this rule. There is not only one way of meeting such a rule but design choices of strong cables, sufficient burial depth, robust equipment, highly reliable components, selection of route to limit interference and so forth are all part of making a network more reliable and a service more resilient                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Part 4<br>Work Rules | All the work rules of Part 4 of the NRSC contribute to resiliency through promotion of a unity of work practices and plant configurations across the country. Therefore in the case of a disaster where widespread damage occurs, workers from different States and parts of the country and different utility companies will be able to work effectively and efficiently together to restore service in a safe and reliable manner. Faster restoration is increased resilience.<br>Unity of work practices, grounding and bonding rules, plant configurations and clearances all promote more reliable interconnections between different utility networks. Common practices and approaches are more easily accomplished when all players use NESC rules as their basic safety rules. This enable interconnection between grids and networks that can help facilitate sharing of resources and flexibility in response to disaster = faster recovery. |

The solution to creating reliable, resilient networks is a complex process with contributions from safety codes, regulatory rules, good design/engineering choices, best operational practices, product specifications and functional performance requirements.

## C.2 Interdependence of Power and Communications

As part of the general effort to improve the national preparedness in case of natural disaster or in response to a planned terrorist attack, government agencies are working to identify effective strategies in four main areas: prevention, protection, response, and recovery. The strategies are designed to adequately prepare the nation and its infrastructure elements to be resilient in the face of major natural or man-made events. The endeavor builds on lessons learned from previous natural disasters and technological

emergencies while using sound judgment and imagination to anticipate new risks and hazards.

An essential part of any effective response and recovery action is the maintenance of an operational telecommunications network and electric power grid to provide continuous flow and exchange of critical information as well as allow the effective monitoring, control and management of infrastructure systems across the country.

As part of the National Preparedness Plan as outlined in *Homeland Security Presidential Directive 8* (2007), an analysis effort with respect to the telecommunications network was needed to fully understand the:

- Current systems and the interdependencies that are inherent in the current networks, and
- Possible effects that emerging technologies may have on the reliability and survivability of both the telecommunications network and electric power grid.

The material below summarizes the findings of a 2008 report on the communications perspective of the interdependencies between telecommunications services and electric utility power supply to help

- (i) develop strategies to reduce the interdependences and
- (ii) improve the reliability of both telecommunications and power supply sectors during disasters and emergencies (i.e., resiliency).

**Note:** *A Report on the Interdependencies Between Telecommunications Services And Electric Utility Power Supply* - March 15, 2008 by Dr. Trevor Bowmer Ph.D.

The report noted above reviewed the interdependencies between telecommunications services and electric power supply in terms of both the current traditional services and the emerging optical-fiber, wireless and Internet-IP technologies. The report also reviewed changes in the regulatory environment and localized powering schemes that may alter the risk profiles for maintaining highly-reliable and resilient telecommunications and power services in the future.

Both communications and power companies employ overlay or backup facilities to help ensure maximum reliability for the networks. Communications has power backup in form of batteries and diesel generators to bridge service demands during power supply disruptions. Similarly, power companies have established supplementary communication systems of wireless, radio, and fiber facilities in case of a problem with their primary internal communications service. Despite these backup reserve facilities, both telecom and power assume that extended disruption or loss of the telecom and utility power services is a low probability event.

The coupling between telecommunications (telecom) and electric utility (power) companies in this discussion becomes evident as the responses of the

telecom network and power grid to various disaster scenarios are considered. The telecom company depends on power company to “keep the juice flowing”, while the power company relies on the telecommunications technologies and industry to keep their internal communications, monitoring and control circuits (e.g., Supervisory Control And Data Acquisition - SCADA) running during disturbances and disruptions.

Key assumptions from that report continue to be applicable up to the present:

- Increased deployment and demand of broadband services over Fiber-To-The-Home (FTTH), Digital Subscriber Line (xDSL), G.fast reverse powering schemes and wireless architectures
- Increased power demand for emerging communications networks
- Localized powering architectures becoming more common
- Wider deployment of alternate energy generation (e.g., wind, fuel cell, etc.) systems for telecommunications networks and systems
- Increased trend towards the use of IP-based networks (including monitoring and control networks) for communications
- Continued deregulation of the power supply and telecommunications industry.

In the construction of the traditional telephone wireline networks, there was mutual agreement and contractual cooperation between communications and power companies to help each other meet and exceed the high reliability targets set for both networks. In the competitive broadband world, there are challenges to maintain the high reliability while:

- (i) Meeting the increasing demands for instant connectivity for the complete range of telecommunications services, and
- (ii) Being prepared for the natural and man-made disasters that will occur (both expected and unexpected).

Improved cooperation between communications and power utilities is a necessary requirement for the future if the high levels of network reliability and service availability are to be maintained.

The major issues and findings from this report are summarized below under several pertinent headings.

### **C.3 Current and Emerging Telecom Network Power**

The Central Office (CO) powering system was originally deployed by communications providers in the 1920s to improve network operations, performance, and reliability. As a result, the combination of flooded lead-acid batteries and diesel generators located in the telecommunications service provider's CO were able to efficiently power both the CO and the customer's telephone in the event of a power outage.

As the electromechanical network evolved first into electronically-switched networks, and now into packet-switched networks over optical fiber cables to meet the enhanced service needs and demands, the power needs of network components required remote powering of telecom nodes at Controlled Environmental Vaults (CEVs), huts, and cabinet sites. These remote sites obtain primary power from the local electric utility AC (Alternating Current) grid and also contain multiple strings of batteries for backup reserve power.

Wireless services have become ubiquitous and higher voice and video quality service is now expected. Wireless and Cable Television (CATV) providers are now seen as competitive providers to the traditional telephony network providers with the expectation of the same high reliability for telephony and the full array of telecommunications services.

The assumption is that the traditional telecommunications companies will evolve or migrate to FTTx (e.g., FTTB, FTTH or FTTP) architectures where optical fiber runs most of the way from CO equipment to the customer residence. Wireless service will expand coverage and service offerings through more efficient processors and improved software-related reconfigurations. Their physical network and fundamental powering architectures will not be significantly changed for the foreseeable future. CATV will improve telephony and IP-based data service offerings through improvements in signal processors and distribution protocols at their headends and within their set-top-boxes (STBs), and not by changing the basic physical networks and powering schemes. As these new transmission architectures develop there will be:

- (i) Significant increases to the total power required to provide telecommunications services to an individual customer,
- (ii) More distributed or localized powering schemes implemented across the networks, and
- (iii) Potential for reduced availability of services at some customer locations during power outages.

### **C.3.1 Communications Powering**

In general, communications companies make provision for up to 72 hours of backup power (stored energy in power plant and diesel for generators) at CO locations. A key component of the powering scheme is backup power are Remote Terminal (RT) sites. These RT sites or nodes are defined for this document as sites where active equipment is deployed outside the CO facilities in CEVs, huts, cabinets and closures. For these nodes, the following backup power practices are typically used:

- Minimum reserve of at least 4 hours of battery backup is standard for RTs.
- Most (>90%) RT sites of large wireline providers are designed with 8 hours of backup power.

- Many remote terminals sites of larger providers have external hookups points for additional power or portable generators (gasoline, natural gas or propane powered).
- A small number (<5%) of critical RT sites have gasoline/natural gas engines built into the cabinet/hut design.

**Note:** Typical functional performance requirements for powering communications systems can be found in GR-513-CORE *Power Requirements in Telecommunications Plant (LSSGR Section 13)* Issue 2, 2010.

As a result of these provisions for backup power in the telecommunication's networks, the effect on communications services (wireless and wireline) of a power outage is not significant until the power outage becomes long or widespread. For such major power outages, the ability to deploy mobile generators to remote site (including cell sites) and the ability to deliver fuel to required locations will determine how long the telecommunications networks continue to supply essential telephony service. Essential service in this context usually includes medical, emergency-911 and alarm monitoring services.

Emerging broadband architectures (e.g., Verizon's FiOS, AT&T's U-Verse, G-Fast reverse powering) are more vulnerable to power loss at the customer premises during long-term outages. Communications services for power facilities (e.g., those used for SCADA systems) are well protected against power outages, power faults, lighting and operational disturbances that occur along generation-transmission-distribution supply networks.

#### **C.3.1.1 Effects of Extended Power Outages**

For this discussion, an extended power outage is assumed to last more than 24 hours and will have the following general characteristics:

- The power outage is widespread and affects not only customer premises (e.g., homes) but the surrounding area including outside plant (OSP), remote terminals and nodes, as well as the CO facility.
- The CO facilities are successfully backed up with diesel generator(s) and batteries with adequate fuel supplies available.
- All RT sites (e.g., Digital Loop Carrier – DLC, DSL Access Multiplexer - DSLAM, fiber nodes) are expected to have at least 8 hours of reserve power as per Ericsson - NIS GRs, the industry's best practices and engineering designs.
- Distribution plans and energy management plans are in place and in operation to supply remote sites with portable generators or additional batteries (if necessary).



- CATV headends and wireless main cell sites are backed up with diesel generator and/or batteries with adequate fuel supplies available.
- CATV set-top-boxes and telecom Broadband Units (BBUs) in FTTH services have 4-8 hours of “talk time” designed into the devices. Some of the more recent units have 12 hours reserve.

The difference between the current traditional wireline architectures and the emerging broadband plant lies chiefly with the increased local powering needed at the customer premises and their reduced ability to provide extended power backup. The local powering of the CPE will limit the telephony backup service to whatever battery reserve is provided in the gateway interface units which is currently between 4 and 12 hours of “talk time”. Having a CO with full running generator and OSP nodes adequately supplied with additional batteries and mobile generators will not extend the ability of the customers in their house to make telephone calls after the battery in their CPE is exhausted.

To maintain telecom services during long outages (>24 hours) or indefinitely would require large capital outlay with small chance of a rapid return on the capital investment. From field trials and equipment performance during actual power outages, various lessons can be, and have been, learned to help maximize reserve power and to reduce network power dependence of telecommunications service. Multiple layers of protection can be added through consideration of the following preventive and mitigation strategies:

- Implement and follow Network Reliability & Interoperability Council (NRIC) Best Practices and other industry guidelines.
- Execute full field trials of emergency procedures following a power outage to determine their effectiveness and provide guidance for improvements in practices.
- Enhance battery replacement program.
- Deploy improved battery and/or power storage technology.
- Use energy efficient products at the customer premises to maximize operational reserve time.
- Institute rapid deployment plans to deploy portable power generators.
- Create networks with modular units, route diversity, and duplication of facilities.

Implementing these strategies will help protect the telecommunications services and also help rapid restoration of services. However, it should be realized that current architectures cannot easily sustain normal telecommunications services during abnormally massive events such as a Katrina-type (e.g., Category 4 or 5) hurricane direct hit on a major city, a Richter Level 9.5 earthquake in California, a massive cyber-attack of the networks, or a nuclear event. The widespread and massive destructive

nature of such incidents results in the physical loss of many COs and multiple remote sites. As a result, communications will be severely disrupted.

For these massive incidents, recovery and restoration plans will be critical to manage the rebuilding of telecommunications networks. These plans may involve extensive deployment of mobile cell tower sites for rapid re-establishment of telecom services and links to the rest of the country and the world. In these events with large scale and widespread destruction of property and infrastructure, the temporary recovery and restoration plans may be very different from traditional telecom services and also from the best solutions for long-term re-building of a telecommunications network.

### **C.3.1.2 Measures to Maintain Telecommunications Service During Power Outages**

Strategies to extend the telecommunications services during a long-term outage include the following:

Better insulate and isolate telecommunications circuits from power disturbances through:

- Plans for rapidly deployable portable power modules such as backup batteries and generators, which can be delivered to RT (remote terminal sites) sites to extend capacity beyond the on-site reserve power.
- Use modular designs for equipment, facility duplication, and route diversity to circumvent the immediate area of damage and provide service through alternate routes and equipment.

Increase the effectiveness and efficiency of operational and recovery procedures used by telecommunications providers in response to extended power outages.

- Procedural measures include full testing/trials of emergency plans, dual routing, redundant equipment and systems, as well as the implementation of the NRIC Best Practices and industry guidelines.
- Maximize use of available reserve power to provide basic telecommunications service to as many individual people, business, industrial and governmental entities for the longest possible time.
- Use energy efficient (e.g., EnergyStar) equipment and energy smart operational protocols to reduce load on batteries.
- Enable customer-specific configuration of backup capabilities in the case of a power outage. Allow operator (or possibly customer) to customize the backup time for each service to match their needs and desires.



- Enhance the capacity of available reserve power through the use of new high energy-density batteries or more frequent replacement of suspect batteries.
- Enhance power reserves at customer premises and local remote sites using Uninterruptible Power Supplies (UPSs), fuel-cell systems, new improved batteries (e.g., Lithium-Ion or Silver-Zinc) and other innovative energy storage devices.
- Reduce energy use in general and grid power consumption in particular of network equipment and facilities through use of energy efficient devices and the use of alternate (off-grid) generation capabilities to increase the diversity of the generation available.
- Diversity of power supply – additional generators, dual feeds to RT sites from different sources.
- The alternate energy sources such as fuel-cell systems, solar and wind generation facilities have unproven reliability, which lead current telecommunications power engineers and Network Operations Departments (who have the responsibility to maintain high reliability) to be reluctant to rely on these new technologies. As the fuel-cell systems and other alternate sources gain acceptance and broader use in all types of sizes and installations, the technical feasibility issues and confidence levels of telecom engineers may be resolved. If the relative cost to the telecom provider can be reduced through technical improvements in fuel-cell production, governmental research grants to encourage alternate energy development or significant increases in the cost of current AC utility power costs, then fuel-cell systems may become more economically attractive.
- Network diversity and facility duplication that protects the physical infrastructure through route diversity and plant duplication. These strategies can be implemented at different levels with a variety of capital and operational costs.
  - Physical diversity in the routes can be achieved by using: (a) traditional buried or aerial plant along widely separated rights-of-way or easements along different roads and highways, or (b) the wireless paths provided through the use of microwave and radio communication technologies and transmitting across the air. The objective is to provide two (2) circuits where it is unlikely that both circuits will fail or be damaged by a single event. This objective may also be achieved with ring architectures (e.g., Synchronous Optical Network - SONET) where the communication circuit is smoothly and instantly healed in the event of local damage to one section of the ring. These ring structures are most efficient when optical fiber

communication and IP-based packet switching technology is being used to supply the service.

- Structural or facility diversity entails designs where the telecommunications cables are routed not only along different routes, but also through different switching nodes (e.g., COs) and/or to duplicate operations control centers for the power utility. Routing the duplicate telecommunications circuits through different COs (telecom nodes) provides multiple backup pathways through IP-based packet-switched technologies. The flexibility provided by such facilities diversity ensures fail-safe operation, assuming that the whole or part of the PSTN remains operable.

### **C.3.1.3 Measures to Enhance Telecommunications Service in SCADA Systems**

The latest industry trends, which are helping to introduce diversity and redundant communications capability into the SCADA networks and related telecommunications services, include the following general strategies:

1. Deployment of all-dielectric optical-fiber cable
2. Wider use of cable route diversity and facilities duplication
3. Increased use of IP-based packet-switched technologies.

The increasing use of all-dielectric, optical-fiber communications circuits has helped alleviate the electrical induced risks associated with the traditional metallic copper cables and networks. The increased use of optical-fiber cables and wireless (radio) communication as either primary or backup communication means for SCADA systems provides opportunities to increase the reliability of the SCADA networks. However, the extension of optical-fiber cables deeper into the local loop and closer to end user customers has resulted in need for local powering of end-user telecom equipment at RTs and on power-station property.

The use of cable route diversity via SONET rings, dual communication feeds or dual operational centers with a duplicate SCADA system, as well as connections to databases and devices, increase service availability.

The convergence of telecommunication networks (PSTN/IP/wireless) and the use of emerging signaling protocols over packet-switched networks introduce several new dimensions including:

- (i) Enhanced capabilities for remote control and operation of power networks from several locations, and
- (ii) Increased risks and possibly attacks in which the control of the power grid may be vulnerable.

As a more diverse range of network types and architectures is used to provide multiple-redundant pathways over which the SCADA system can

operate, the number of interconnections and access points will increase rapidly. As a result of these multiple access points, the cyber security and access control issues will become more critical and a significant management control issue. Multiple firewalls need to be established with strong mutual authentication protocols followed. Active data integrity protection schemes will be needed. The cyber security issues can be managed with due care and attention to the technical, software firewalls, physical access control, and human factor aspects of system protection.

#### **C.3.1.4 Summary of Strategies to Maintain Telecommunications Services**

The general recommendations to maintain communications service during power outages and disturbances are provided below in terms of both physical infrastructure suggestions and operational protocol strategies.

##### **Physical Infrastructure:**

- Deploy increased battery storage and/or generation capacity at customer premises and at remote terminal locations.
- Deploy new storage technologies to increase power reserve capacity – e.g., UPS, higher capacity battery technologies (lithium-ion batteries).
- Develop and field test emergency plans that include rapid deployment of portable generators to critical service nodes at remote terminals in the outside plant. Full field simulations to evaluate emergency response plans and procedures should be scheduled at least every two (2) years. These simulations shall include building blackout testing during extreme summer and winter temperature conditions, regardless of the tenants. Such a full building blackout test is designed to ensure that:
  - All necessary building AC loads are on the generator's standby bus
  - The generator is properly sized for the building
  - The generator's "life support" systems (e.g., fuel pumps, oil cooler pumps, water pumps, start battery charger, etc.) are powered from the generator they are serving
  - These parameters are measured during periods of peak demand, and/or worst ambient environmental conditions
  - Critical office facilities and communications systems are powered from the generator
  - The office emergency lighting system is working properly.
- Conserve energy use to maximize reserve time of available power, through using more energy efficient equipment and/or improved operational protocols to reduce operational power use.
- Use network and route diversity to circumvent damage zone and supply telecommunications circuits and services through an alternate

pathway:

- ☐ Maintain dual cables, paths, and operational facilities
- ☐ Use duplicate networks – microwave, copper, fiber, cellular, etc.
- Power Generation Diversity – implement new alternate energy systems (e.g., fuel-cell systems, wind systems, solar panels, etc.) to make power supply for telecommunications independent of the AC power grid.

The above strategies are focused on the physical and technical measures that can be used to help the infrastructure better deliver telecommunications. There are also various operational strategies that can greatly improve the reliability and availability of telecommunications networks and services including the following suggestions.

#### **Operational Protocols:**

- Complete full-scale test of emergency procedures for networks and facilities
- Full tests of backup systems to determine the effectiveness of power backup capacity and efficiency of secondary and dual-power delivery systems
- Implementation of plans for rapid deployment of portable batteries and generators to remote sites to supplement reserve power.

Tests of these emergency plans are important not only to evaluate the logistics of the plan but also to evaluate the human factors critical to the successful implementation of these emergency plans. The ability of telecom and electric utility workers to get the job done requires the ability to get the correct information to the right person, at the right time.

Another more complex human factor to an emergency plan's success is the education of the public, business and governmental customers of these telecommunications services. Expansion of the public education program covers

- (i) what can be expected to happen to their telecommunications services during power outage, and
- (ii) what personal actions they can possibly take to maintain telecommunications service as long as possible during the power outage.

The psychology, public policy and politics of emergency notification and public education programs are outside the scope of this report.

Whatever approach is used to attain the necessary or desired levels of reliability, resilience and service availability there will be a need to

- Develop an economic analyses to determine the reasonable return of investment and total lifetime costs for the technical measures and compare these costs with a quantitative measure (cost) of the potential service disruptions and outages that can result from the various disaster and emergency scenarios.
- Complete full-scale tests of operational effectiveness under disaster conditions and emergency responses and evaluate the actual performance of current networks relative to their as-designed responses and the NRIC Best Practices and industry guidelines (i.e., a gap analysis).
- Provide technological assessments of the best new alternate power technologies to supplement or replace AC power grid supply.
- Define and evaluate various recovery and restoration plans that can provide rapid response to massive incidents (e.g., Richter scale 9.5 earthquake or denotation of nuclear device) that require extensive rebuilding of communications networks. These plans may involve extensive deployment of mobile cell tower sites for rapid re-establishment of telecom services and links to the rest of the country and the world. In these events with large scale and widespread destruction of property and infrastructure, the temporary recovery and restoration plans may be very different from traditional telecom services (e.g., satellite-based systems) and also different from the best solutions for the long-term rebuilding of the communications network.

#### **C.4 Communications Impacts of Historical Disruptive Events**

To illustrate the effects of small and large disruptive effects one can review historical events including floods, fires, hurricane damage, ice storms, and terrorist attack. The scenarios described below originate from the experience of individuals and teams at Ericsson - NIS (previously Telcordia/Bellcore and Bell Laboratories) who have over the years provided disaster recovery services, product failure analysis, and network design evaluations.

##### **Small Scale, Localized or Momentary Power Problem**

Examples are a lightning or power surge damage to telecom site with manual or automatic re-setting of equipment and recovery. The lightning surge or power cross sends a spike or surge into CO and operates fuses. It is a rapid event over in 1-2 seconds with possibly 15-30 minutes to recover because of the possible need to manually re-set equipment. As long as no fire occurs or any permanent damage happens to the telecommunications equipment, such an event is easily recovered from at all locations where the equipment has been tested to industry standards such as GR-1089 or GR-63 (NEBS).

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All the telecommunications carriers – wireline, wireless and CATV companies – design their plants for such scenarios since lightning events and power sags are well known and their impact on equipment can be simulated and anticipated. Concerns can arise if non-standard CPE devices are installed at the customer sites and interconnected into the telecommunications network interface units (STB, modems, etc.).

Equipment and products not tested to industry standards for performance or UL (Underwriters Laboratories) safety requirements can pose a hazard to people and the network.

### **Major Link Failure or Physical Damage to Telecom Facility**

In January 1991 and November 1988, there were incidents when major optical-fiber links were severed in the northeast U.S. near New York City, which resulted in loss of 911 Service and airport traffic control, as well as New York Stock Exchange and Mercantile Market circuits. The damage event only took 5-10 minutes to unfold but many hours to restore service and longer (many days) to completely repair the link.

| <b>Estimated Consequences – Major Link Damage</b> |           |
|---------------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines                 | 200,000   |
| ♦ Degraded Service or affected service            | 40,000    |
| ♦ 911 – critical service lines lost               | 4-6       |
| ♦ Blocked Calls                                   | 4,000,000 |

In the case of a large fire in a central office (e.g., similar to 1988 Hinsdale CO Fire, or 1986 Bushwick CO fire), the damage to the facility can be extensive both from immediate fire damage and effects of corrosive fumes on adjacent electronic equipment. It took 10 days to 2 weeks to restore service with a few months to eventually replace and repair the entire network.

| <b>Estimated Consequences – Large Fire</b> |           |
|--------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines          | 70,000    |
| ♦ Degraded Service or affected service     | 80,000    |
| ♦ 911 – critical service lines lost        | 5-6       |
| ♦ Blocked Calls                            | 4,000,000 |

Several 2007 fires in California threatened over 2,000 homes and caused large scale evacuations. The spreading wildfires were difficult to contain and spread across wide areas affecting a number of communities. The event developed over many days and the recovery work was still ongoing to the housing and infrastructure after many weeks.

| <b>Estimated Consequences – Localized Wild Fires</b> |       |
|------------------------------------------------------|-------|
| ♦ Service lost to Customers/Lines                    | 2,000 |
| ♦ Degraded Service or affected service               | 4,000 |

Commercial power and telecommunications was available for the duration of all these major link incidents described above outside of the immediately affected areas. It was not the lack of commercial power that affected telecommunications services during these events. In the cases of heavily-damaged COs there was no service because of the physical damage and it makes no difference if there was 4 hours or 100 hours of battery reserve at the OSP remote terminals or inside customer premises equipment.

During the California wildfires, the major wireless and wireline carriers reported that their networks continued to perform at near-normal levels despite the disruptions created by the wildfires. AT&T reported that more than 99 percent of its cell sites in Los Angeles, Orange, San Bernardino, and Ventura counties were functioning normally as consumers continued to complete calls, send and receive text messages, access e-mail, and connect to the Internet. Although the fires affected 25 AT&T cell sites in the Los Angeles, San Bernardino and San Diego areas, those were repaired and restored quickly within a few days. However, since the people were evacuated from the areas where fire damage was worst, there were no wireline customers in their houses or wireless customers in the street to attempt to make calls.

A Verizon spokesman said of their wireline service that there were 984 lines out of service in its Southern California service area due to the fires, and 15,814 lines are running on generators or batteries. In the Verizon serving area, 16,798 customers were without commercial power. Some outages were the result of direct fire damage to Verizon lines and equipment, and others were attributed to drained backup batteries in electronic equipment in areas that lost commercial power. As for AT&T wireline service, the company stated that due to severe burn damage to a 9-mile fiber connection, the communities of Julian and Warner Springs remain isolated; able to make calls within the community but not beyond.

In the incidents of heavy damage to the Hinsdale and Bushwick COs, the affected wireline companies set up temporary communications sites (wireline and wireless services) with free calling and access to Internet.

The general conclusion from these examples is that the effect on telecommunications services (wireless and wireline) was not great and was independent of the commercial power availability. In particular, the wide customer use of both wireline and wireless communications services provides insurance for both systems. Customers were likely to communicate through one or another of the networks. The ability to deploy mobile

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generators and cell sites greatly alleviated the consequences to both wireline and wireless service networks.

### Power Outages – General Discussion

For a short power outage of less than 2 hours localized to a small area (e.g., covering a few COs), there is minimal effect on telecommunications services. The design of the power backup system for all telecommunications architectures – wireline, wireless and CATV – operates as expected and continues to provide telephony service.

Service at some telecom customers may be lost or affected because of local CPE failure (e.g., no power for cordless phones). If the power outage is across a wide geographic area, then traffic congestion and denial-of-service events will increase. Businesses may be significantly affected since many exclusively use cordless phones, smart phones, small PBXs and other multiline telephony systems that would be disabled by an AC power grid failure at their location.

| Estimated Consequences – 2-4 hours Power Outage |       |
|-------------------------------------------------|-------|
| ♦ Service lost to Customers/Lines               | 4,500 |
| ♦ Degraded Service or affected service          | 200   |
| ♦ 911 – critical service lines lost             | 0-1   |
| ♦ Blocked Calls                                 | 100   |

In the case of longer power outages of 2 to 8 hours, there are still only minor effects on the telecommunications customers and networks. The loss of utility power activates the planned power backup of switching to generators and battery backup. There will be some resulting traffic congestion that may deplete that reserve faster than anticipated, but backup power will ensure service is maintained with some 10-20% of affected RTs likely to experience reserve power problems (e.g., lower than expected battery capacity). CO equipment is unaffected and maintains basic POTS, although some broadband services may be lost.

For long power outages of >20hours over a localized geographic area, the remote terminal units will exhaust their 8 hours reserve. As seen in the experience with the California wildfires, if the affected geographic area is contained then mobile generators and additional backup batteries can be deployed to the RT sites and basic telephony service was maintained.

For extended power outages of >20 hours over a wide geographic area, the possibility of disruption increases substantially since the telecommunications provider may exhaust its capacity to provide mobile generators and replacement batteries to all the affected RT sites, and fuel supplies may become scarce.

| <b>Estimated Consequences – Widespread 48 hour Power Outage</b> |           |
|-----------------------------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines                               | 400,000   |
| ♦ Degraded Service or affected service                          | 10,000    |
| ♦ 911 – critical service lines lost                             | 1-2       |
| ♦ Blocked Calls                                                 | 1,000,000 |

The general conclusion from these power outage examples is that the effect on telecommunications services (wireless and wireline) was not great until the power outages became abnormally long or widespread. During short power outages, the telecommunications networks and their backup power emergency plans will operate as planned. For longer outages, the ability to deploy mobile generators and cell sites and obtain regular fuel supply will determine the ability of the telecommunications networks to continue to supply essential lifeline telephony service.

### **Major Power Outage – Northeast Blackout of 2003**

According to the North American Electric Reliability Council report of 2004, ineffective vegetation (tree) management help initiate a fault on a 345 kV transmission line, which resulted in a generation resource problem that propagated owing to computer problems, operator error, and misinterpretations.

| <b>Estimated Consequences - 2003 Northeast Blackout</b> |           |
|---------------------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines                       | 280,000   |
| ♦ Degraded Service or affected service                  | 200,000   |
| ♦ 911 – critical service lines lost                     | 0-1       |
| ♦ Blocked Calls                                         | 1,000,000 |

One major regional telecommunications provider lost five (5) switches in two “high-profile” CO facilities in Manhattan when standby generator failed to operate. The loss of HVAC at these sites caused high ambient temperatures and high humidity conditions, which resulted in (i) decreased output from the turbine-driven generators, as well as (ii) fuel delivery system issues with two of the diesel generators. These troubles affected service to 276,000 customers. However, the vast majority (>99%) of the provider’s standby generators started, transferred, and assumed the critical office loads, as designed.

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## Major Plant Damage Events

In the case of heavy and widespread hurricane damage or results from a major earthquake then infrastructure damage to power lines, COs, and OSP structures cannot be easily circumvented by the backup powering architectures of any telecommunications networks.

Hurricane Andrew hit Dade County (Florida) on August 24, 1992 traveled across 1,500 square miles of Florida, out over the Gulf of Mexico, and then back onto U.S. land along the Gulf Coast (Florida, Louisiana and Mississippi) affecting 1-2 million in Florida and 300-500 thousand in Louisiana and Mississippi. The event took 3-4 days to unfold, but the exact landfall in Florida was not anticipated to allow for significant advance warning and preparation.

| Estimated Consequences – Hurricane Andrew |           |
|-------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines         | 1,750,000 |
| ♦ Degraded Service or affected service    | 1,000,000 |
| ♦ 911 – critical service lines lost       | 10-12     |
| ♦ Blocked Calls                           | 5,000,000 |

Hurricane Katrina hit New Orleans and the surrounding Gulf States area in August 2005 with the city infrastructure destroyed. Over 1,000,000 telephone lines were disrupted with 250,000 remaining out of service 4 weeks after the storm event. More than thirty-five 911 call centers were down with two call centers down for more than 4 weeks. 1,500 cell sites were damaged with several hundred remaining out of service 4 weeks after event. Ring structures broke in multiple locations resulting in loss of network redundancy. Refueling of generators became impossible and portable generators were not easily deployable because of combination of water damage and physical damage.

A high-speed Internet cable was found to be “live” and operable in Gulfport, MS. A mobile Cell-On-Wheels (COW) unit was brought to the location and a large cell site was established that helped provide cellular telecommunications in this local area. This was an example of linking different telecommunications architectures together to obtain continuity of service.

| Estimated Consequences – Hurricane Katrina |           |
|--------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines          | 1,000,000 |
| ♦ Degraded Service or affected service     | 500,000   |
| ♦ 911 – critical service lines lost        | 35        |
| ♦ Blocked Calls                            | 5,000,000 |

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The terrorist attack of September 11, 2001 resulted in the destruction of the World-Trade-Center (WTC) and the switching center it contained as well as the transmission towers and broadcast capabilities installed on the roof of the towers. In addition, many of the adjacent and nearby buildings were affected including a major CO at 140 West Street Office. Part of the outer wall was destroyed falling debris and large amounts of fine dust contamination was spread into the switch and toll equipment of the CO. Despite the physical damage and contamination, much of the CO equipment remained operational.

| <b>Estimated Consequences – WTC Attack</b> |            |
|--------------------------------------------|------------|
| ♦ Service lost to Customers/Lines          | 40,000     |
| ♦ Degraded Service or affected service     | 150,000    |
| ♦ 911 – critical service lines lost        | 5          |
| ♦ Blocked Calls                            | 15,000,000 |

A major earthquake of Richter Scale 8 can produce significant physical damage across a wide area to OSP aerial cable facilities. No functional operational damage at major COs occurs since they are built to NEBS standards that will make these events survivable without significant loss in service. Aerial plant has some problems with falling poles, downed wires and lost utility power. Buried plant should be 95% safe. Cabinets and pedestal and huts should all survive unless they are at the epicenter with larger dangers being from collateral effects such as traffic congestion, fires, and floods from broken pipes.

| <b>Estimated Consequences – Earthquake (Richter 8)</b> |            |
|--------------------------------------------------------|------------|
| ♦ Service lost to Customers/Lines                      | 25,000     |
| ♦ Degraded Service or affected service                 | 200,000    |
| ♦ 911 – critical service lines lost                    | 10         |
| ♦ Blocked Calls                                        | 10,000,000 |

Widespread flooding such as occurred in 1997 across the Midwestern U.S. damaged a number of CO facilities and OSP node sites in the vicinity of the Red River valley covering over 100 counties in North Dakota and Minnesota. This 500-year flood event covered many acres of agricultural land, inundated 10-15 COs and their surrounding local loop distribution areas. Stray current corrosion and foreign voltages were a persistent problem during the long recovery time over many weeks. The backup powering architecture of the telecommunications system aggravated the stray current and water induced short problems since the power system is designed to maintain power on the shorted lines. Manual intervention was necessary to pull heating coils, sand bagging of offices, pulling line cards and eventual disconnection of power to limit damage and allow recovery.

| <b>Estimated Consequences – Major Floods</b> |           |
|----------------------------------------------|-----------|
| ♦ Service lost to Customers/Lines            | 50,000    |
| ♦ Degraded Service or affected service       | 50,000    |
| ♦ 911 – critical service lines lost          | 2-4       |
| ♦ Blocked Calls                              | 1,000,000 |

These types of events with heavy and widespread physical damage to OSP facilities, power lines, COs and related structures cannot be easily circumvented by the backup powering architectures of any telecommunications network. It is not feasible to harden telecommunications plant or construct economic backup powering schemes that can eliminate the effects of such major disruptive events.

### **Cyber Attack**

A cyber-attack could initiate cascading failures in equipment and in the Signaling System #7 (SS7) protocols. In the early 1990s, the SS7 switch systems had a shutdown which cascaded through the network with communications between nodes being shut down and propagation from node to node extending across the whole country. One of the largest software failures was the 1990 SS7 failure event that tied up offices and congested traffic.

| <b>Estimated Consequences – Cyber Attack</b> |            |
|----------------------------------------------|------------|
| ♦ Service lost to Customers/Lines            | 10,000,000 |
| ♦ Degraded Service or affected service       | 10,000     |
| ♦ 911 – critical service lines lost          | 30         |
| ♦ Blocked Calls                              | 10,000,000 |

Similar software related failures that caused large traffic congestion issues and interoffice communication problems happened in

- 1991 initiated by a software error
- 1998 caused by a failure in a Frame Relay (FR) that had ripple effects (traffic congestion and denial-of-service) across the nation
- 1997 when a provider lost "800" Service for 90 minutes
- 1998 NYC Mercantile Exchange problems.

The powering architecture for the telecommunications networks has no effect (positive or negative) on these cyber-attack and software related

events. In some respects the reliability of the network through the power backup system helps to propagate the problem across the telecommunications network.

## **Solar Flares and Magnetic Storms**

Explosions on the sun surface generate solar flares and magnetic storms, which release highly energetic particles that travel outwards and produce strong magnetic storms in the earth's atmosphere. These storms can affect satellites, cables, power systems, and wireless communications.

Satellites are damaged by direct impact from the energetic particles from the sun. Cable communication can be disrupted through problems associated with induced currents and ground potential rise effects resulting from the ~6 volts per kilometer gradients caused by the solar storms impacting the earth's atmosphere. These increased ground potentials also effect power circuits. The charged particles (ions) generated by the solar activity also interfere with radio and wireless communications.

The activity peaks every 11 years with the next high level of solar activity predicted for this year (2008). In the last incidents during January 1997, an AT&T satellite broadcasting TV programming completely failed which was tentatively attributed to the solar flares. During a March 1989 storm, communication across transatlantic and transpacific cables was degraded (high attenuation and high noise levels). During the same 1989 storm, parts of Montreal and Quebec were without power for 9 hours after aurora currents in the air raised the ground potential and induced significant currents in cables that disrupted and overwhelmed SCADA control systems of the local power grid.

## **C.5 Protective Measures**

The difference between traditional architectures and the expanding broadband services lies chiefly with the reliance on localized powering schemes at the customer premises and their reduced ability to provide extended power backup to the CP sites and CPE equipment in the case of:

1. Major disaster when AC power is lost for long periods over extended geographic areas
2. Widespread damage from major hurricanes that destroys COs and substantial amount of infrastructure
3. Losses become more sustained (i.e., days or weeks) and widespread. A crippled or destroyed power station could take years to re-build.

The local powering of the CPE will limit the telephony backup service to whatever battery reserve is provided in the gateway interface units which is currently between 4 and 8 hours of "talk time". Having a CO with a full running generator and OSP nodes adequately supplied with additional

batteries and mobile generators will not extend the ability of the customer in their house to make telephone calls after the battery in the CPE is exhausted.

It is important to place the effects of power outages on communications in context with the broader concerns documented in the National Planning Scenarios raised in the Homeland Security Presidential Directive 8 (HSPD-8) – “*National Preparedness Guidelines* (see table below). For each of the 15 different scenarios listed, the expected impact to telecommunications services will be briefly described.

| <b>National Planning Scenarios (from HSDP-8)</b> |                                  |
|--------------------------------------------------|----------------------------------|
| A. Improvised Nuclear Device                     | I. Major Earthquake              |
| B. Aerosol Anthrax                               | J. Major Hurricane               |
| C. Pandemic Influenza                            | K. Radiological Dispersal Device |
| D. Plague                                        | L. Improvised Explosive Device   |
| E. Blister Agent                                 | M. Food Contamination            |
| F. Toxic Industrial Chemicals                    | N. Foreign Animal Disease        |
| G. Nerve Agent                                   | O. Cyber Attack                  |
| H. Chlorine Tank Explosion                       |                                  |

### **Improvised Nuclear Device**

An improvised nuclear device attack would cause a nuclear blast with an immediate zone of damage and an outer zone of fallout where contamination and radiological damage would make recovery efforts difficult and slow. Electromagnetic Pulse (EMP) disruptive effects will be felt in telecommunications and electric grid supply network equipment.

In the immediate blast zone, electric grid and utility power as well as telecommunications facilities will be severely damaged to levels commensurate with the WTC attack spread over a much larger area. One should assume that 2-4 COs and associated distribution areas would be directly affected with the adjacent 10-20 COs being disrupted and contaminated.

This type of event with heavy and widespread physical damage to OSP facilities, power lines, COs and other facilities cannot be circumvented by specific backup powering architecture of any telecommunications networks. It is not feasible to harden telecommunications plant or construct economic backup powering schemes that can eliminate the effects of such major events.

Recovery will be slow because the contamination in the surrounding area will make it very difficult to send repair and restoration teams into the area.

The mere presence of radioactive fallout and pollution dust from the blast in telephone equipment will not necessarily cause failures in circuits and facilities. Equipment will continue to operate with decreased reliability from the possible electrical shorts caused by the dust and debris getting into electronic equipment and connections.

Telecommunications disaster recovery planning would need to include the delivery of mobile communications centers (cellular, radio, satellite and microwave systems) with portable generators to supply electric energy from outside the affected area to augment any surviving systems.

### **Aerosol Anthrax**

This incident involves an intentional dispersal of a biological active agent in an aerosol over a wide area. Telecommunications and electric supply network and support equipment will function normally despite the presence of anthrax spores or associated aerosol agents. The long-term threat to telecommunications service from such an event comes from the inability of workers to enter facilities in the contaminated area to perform routine maintenance and operational tasks.

Such tasks could be partially accomplished by workers wearing protective suits. Recovery time would be long because of the need to prevent fresh outbreaks during clean up procedures in telecommunications network facilities.

The large problem could be finding adequately trained personnel because the usual staff with the best local knowledge would also be more likely to be affected and incapacitated by the attack.

As seen from the results of the recent Covid-19 pandemic, society was able to manage with extensive amount of remote work from home only providing essential services including medical, food providers (supermarkets), postal, package deliver, fuel delivery, and other workers can continue. However, the physical and psychological stress of such situations can become debilitating on all people.

### **Pandemic Influenza**

This incident involves an intentional dispersal and/or spreading of a disease through deliberate spreading by sick individuals, physical dispersal using an aerosol or water-borne agent.

Similar to the anthrax aerosol case described above, telecommunications and electric supply network and support equipment will function normally. The short-term threat to telecommunications service from such an event comes from the restrictions placed on workers to move easily around the contaminated area and enter facilities in the contaminated area to perform



routine maintenance and operational tasks.

As in the Anthrax case above, the long-term problem for telecom operations will be the disruption to workers and the ability to find adequate personnel with the local knowledge to maintain and repair equipment and facilities.

The recent (ongoing) Covid-19 pandemic is such an event. Society was able to manage with extensive amount of remote work from home only providing essential services including medical, food providers (supermarkets), postal, package deliver, fuel delivery, and other workers can continue. The communications system with internet conference calls and emails and other myriad of means to communicate did help alleviate the effects for a large portion of the population. However, the physical and psychological stress of such situations can become debilitating on all people.

The key factor is to keep the contamination and cross infection rate from such diseases (anthrax or influenza) as low as possible to enable the operation of services by vaccinated, healthy individuals.

## **Plague**

This incident follows a similar scenario as for the Anthrax and Influenza events with comparable effects on the telecommunications and electric power infrastructures. Plague and influenza also carry with them the contagious hazard of rapidly spreading to adjacent areas, other cities and other countries because of the ease of movement and international travel in the world.

Telecommunications and electric supply network and support equipment will function normally during and after the event. The short-term threat to telecommunications service from such an event comes from the restrictions placed on workers to move easily around the contaminated area and enter facilities in the contaminated area to perform routine maintenance and operational tasks. Restrictions on travel and quarantine requirements will disrupt the ability of bringing expert technicians into the affected area to replace incapacitated people, and to transport needed fuel and telecommunications equipment resources into the affected area.

As in the Anthrax and Influenza cases above, the long-term problem to telecom operations will be the disruption to workers and the ability to find adequately trained personnel with the best local knowledge to maintain and repair equipment and facilities.

## Blister Agents

In this case, blister agents such as mustard gas are suggested as possible agents to sicken and incapacitate individuals through air-borne dispersal (from aircraft).

Telecommunications and electric supply network and support equipment will mostly function normally in the initial stages. Depending on the nature of the irritant agents, its concentration and local weather conditions (humidity and temperature), corrosion of telecommunications equipment, exposed metallic wires and surfaces, connections and printed circuit boards is a possibility.

The short-term threat to telecommunications service from such an event comes from the restrictions placed on workers to move easily around the contaminated area and enter facilities in the contaminated area to perform routine maintenance and operational tasks. In a short time (few hours to one day), the blister agent is expected to disperse or react with surfaces. Apart from the problems with travel and access restrictions as a result of the attack, telecommunications equipment may experience some additional troubles caused by chemical reactions of the blister agent itself or a carrier gas or liquid.

Short-term contact with the blister agent could corrode metallic backplanes, terminals and connection pins of equipment. The chemical-induced corrosion can create multiple short circuits and trip protection panels in the telecommunications closet and even back in the CO facility.

Small scale corrosion that does not initiate immediate problems can produce long-term effects if the corrosion process spreads from the initially exposed areas. Absorption of the blister agents on to plastic, metallic and ceramics surfaces can initiate corrosion and chemical degradation of connection equipment, terminations and printed circuit board components. Corrosion products absorb water from the ambient air and help accelerate and spread the corrosion. The trouble report rate for a switch can then grow exponentially until the switch needs to be replaced several months after the blister attack. See scenario H (chlorine explosion) below for descriptions of related effects.

## Toxic Industrial Chemicals

In this case, the active agents can include heavy metals (e.g., lead, cadmium), hazardous solvents or toxic organic materials (e.g., isocyanates, nitriles) that would primarily initiate long and short-term illness and incapacitate individuals.

The short-term threat to telecommunications service from such an event comes from the health and safety restrictions placed on workers to perform routine maintenance and operational tasks. Ease of movement is restricted

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around the contaminated area and in telecom facilities in the affected area.

Telecommunications and electric supply network and support equipment will function normally, unless the event occurs directly inside a telecommunications facility. Collateral effects from a nearby chemical spill should not expose the equipment to a significant concentration of the chemical to impact the operation or long-term reliability of the equipment. Some stress cracking or corrosion of materials used in the equipment is possible but the levels should not be such to require extraordinary maintenance or restoration efforts.

However, if the chemical is in concentrated form and the telecom equipment becomes saturated with the chemical then permanent damage to the equipment shall be expected it is likely the equipment will need replacement. The recovery and restoration of the equipment is possible through careful cleaning protocols, although the cost of cleaning a heavily damaged unit can approach or exceed replacement costs.

### **Nerve Agent**

The consequences of an attack with Sarin or some other organo-phosphate nerve agent would be similar to that described above for the blister agent attack scenario, but with a reduced danger of damage to the telecommunications equipment or materials. Telecommunications and electric supply network and support equipment should function normally.

### **Chlorine Tank Explosion**

Since there are approximately 800,000 shipments of hazardous materials by truck every day in the U.S., the possible accidental release of hazardous gases like chlorine is not an unlikely event. The possible impacts can be accurately estimated based on the railcar accidents that have occurred and one particular event that occurred in Graniteville, SC. At Graniteville, a train crash fractured a tanker car of chlorine gas. The heavy gas spread quickly downhill from the accident site flowing down valleys and along low lying creek beds. The small town where the incident occurred suffered 9 deaths. In a larger town or city, the death toll would have been much greater. The industrial-residential area of the crash included a telecommunications CO and various data centers and remote terminal huts.

Telecommunications and electrical supply network and support equipment exposed to the high concentrations of chlorine gas suffered rapid loss of service with electrical shorts caused by heavy copper corrosion and dripping of corrosion products from connections, terminals, bus bars and any exposed metallic surfaces in the immediate vicinity.

The whole incident area including the CO could not be entered for many

days until the chlorine levels subsided. Therefore, telecom personnel will not be able to enter facilities to restore services or manage service disruptions. Full assessment of damage to plant needed to wait for many weeks until the area was stabilized.

All metallic surfaces exposed to the gas will experience corrosion. Chlorine gas is heavier than air and will remain close to the ground unless the weather is windy. If high winds are present the chlorine gas will disperse quickly. Therefore, telecom aerial plant located more than 12 feet above ground will not be greatly damaged. The gas will permeate buried plant in pedestals and cabinets and initiate corrosion of ground wires and terminals. The closures do provide some protection to mitigate exposure.

Although the switch equipment inside COs and huts have additional levels of air filter protection, the racks and shelves of equipment have many terminals, connection, backplanes and printed circuit board components that can be damaged by direct exposure to chlorine gas and other gases. The impact of the event is proportional to the concentration of the chlorine.

Data centers immediate adjacent to the tanker were covered in liquid corrosion products that destroyed the equipment and caused electrical shorts and electrical protection problems in the central office. The shorted connections in the remote data center were seen as operating services that placed a huge load on the CO.

The equipment inside the CO located 100-200 yards from the tanker incident initially showed only minimal visual damage from the exposure to the gas. The downhill contour of the land helped direct the chlorine gas away from the CO. However, evidence of surface corrosion on backplane pins of switch equipment was found that in the long-term would require the replacement of the switch.

Exposures to chlorine, blister agents and other reactive chemicals will cause metallic surface damage in most telecommunications' equipment. The product specification for this equipment includes various environmental stress tests and corrosion resistance tests to simulate normal operational exposure dust particulates, pollutants and moisture. Equipment that meets these product specifications will be able to survive an exposure to small or moderate levels of these chemical and operate reliably afterwards. Exposure of equipment to high concentrations of chlorine or other active chemicals must be expected to cause the high troubles.

In the Graniteville case, local aerial plant and buried plant survived with some minor damage that was repaired as part of regular maintenance work. Switch equipment in the near vicinity (i.e., exposed to high concentration) is heavily damaged and causes service problems and denials in the nearby COs.

## Major Earthquake

Earthquakes of Richter scale 5-6 will have minimal to moderate disruption effects and even those of Richter scale up to 8 to 8.5 will be survivable with much, if not most, of the telecommunications network and equipment still operable.

If not located at the epicenter, major COs should experience minimal functional operational damage since they are built to NEBS standards that will make these events survivable without significant loss in service. This assumes that the location is appropriately rated as an earthquake zone and the installed equipment has been designed and tested to that zone level.

Aerial plant may have some problems with falling poles, downed wires and lost utility power. Buried plant should be 95% safe. Cabinets, pedestals and huts should all survive unless they are at the epicenter. Short and long power outages would be expected.

Earthquakes of greater than Richter Scale 9 will cause major damage to all parts of telecommunications and electric supply networks. CO buildings and structures are not engineered or designed for such stresses. Power and telecommunications services will be widely lost and will only be restored when outside help, replacement equipment, mobile switching stations, portable generators and mobile cellular sites can be brought in from outside the immediate earthquake zone.

## Major Hurricane

In the case of heavy and widespread hurricane damage or results from a major earthquake then infrastructure damage to power lines, COs, and OSP structures cannot be easily circumvented by the backup powering architectures of any telecommunications networks.

As an example Hurricane Katrina hit New Orleans and the surrounding Gulf States area in August 2005 with the city infrastructure destroyed. Over 1,000,000 telephone lines were disrupted with 250,000 remaining out of service 4 weeks after the storm event. More than thirty-five 911 call centers were down with two call centers down for more than 4 weeks. 1,500 cell sites were damaged with several hundred remaining out of service 4 weeks after event. Ring structures broke in multiple locations resulting in loss of network redundancy. Refueling of generators became impossible and portable generators were not easily deployable because of combination of water damage and physical damage.

The use of mobile Cell-On-Wheels (COW) unit and rapid restoration large cell site to re-establish wireless communications quickly coupled with extensive help from surrounding unaffected communities along with repair/restoration crews from adjacent utilities and states under mutual aid agreement to re-construct or repair damage physical wireline infrastructure.

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## Radiological Dispersal Device

This scenario is usually described as a “dirty bomb” attack where:

- A radioactive “dirty bomb” consisting of a conventional explosive combined with radioactive cesium-137 material is detonated in an urban business area.
- The detonation “blast and shock wave” does not directly impact telecom CO facilities, but the resulting radioactive dust plume passes over the CO building. The time for the radioactive dust plume to reach the CO is dependent on wind speed and distance from the blast zone.
- The radioactive dust plume contaminates external facility surfaces by settling and is entrained into the CO’s air intakes and distributed through air ducts causing internal facility and equipment contamination.
- Commercial AC power is not interrupted as a result of the “dirty bomb” detonation.
- The scenario will not afford adequate time for on-site CO personnel to seal air-intakes.

Telecom network and support equipment will function normally based on the expected radiation levels resulting from the distribution of cesium-137 particulate/dust. There is no expected long-term degradation or enhanced failure rate to network equipment materials or devices based on the radiation levels expected from the cesium-137 dust particulate contamination. Widespread contamination with cesium-137 particulate/dust of facility and network and support equipment would be expected based on air handler operation and would require a detailed survey to determine the extent of contamination and cleaning.

The dust contamination of the equipment can be expected unless the air handlers can be closed rapidly to prevent outside air entering the facility. The physical presence of dust on equipment can create long-term problems since the dust will be hygroscopic and absorb water from the ambient air and initiate electrical short and corrosion reactions. As long as the radiation levels are not too high, there are standard cleaning protocols to remove dust contamination from telecom equipment that can be modified and employed to restore the equipment quickly.

Short-term effects to telecommunications service from such an event mainly comes from the restrictions placed on workers to move around the contaminated area and enter facilities in the contaminated area to perform routine maintenance and operational tasks.

## **Improvised Explosive Device**

The effects would be similar the effect of the WTC attack described earlier with major damage to cable links and CO facilities. As long as the equipment is not damaged by the immediate blast effect, the major secondary problem will be contamination from the dust and debris spread by the explosion.

One can expect the dust and debris contamination will enter telecommunications facilities through fans, air handler systems. Outside plant are normally designed to resist high levels of dust and should not be adversely affected. There are standard cleaning protocols to remove dust contamination from telecom equipment that can be employed to restore the equipment quickly.

## **Food Contamination**

This threat follows the same scenario and effects on telecommunications personnel as described above under scenarios for Anthrax, Influenza, and Plague attacks. The short-term threat to telecommunications service comes from incapacitated workers. The direct effect on telecommunications equipment should be minimal since the contamination agent is not expected to be in contact with the equipment.

## **Foreign Animal Disease**

This threat follows the same scenario and effects on telecommunications personnel as described above under scenarios for Anthrax, Influenza, and Plague attacks. The short-term threat to telecommunications service comes from incapacitated workers. The direct effect on telecommunications equipment should be minimal since the contamination agent is not expected to be in contact with the equipment.

## **Cyber Attack**

A successful cyber-attack could initiate cascading equipment and switching failures as well as create electric power supply problems. In some ways the backup powering schemes that are designed to maintain telecommunications and power service will help to propagate the cyber-attack by maintaining the lines of communications and cable links for the cyber-attack to move across the country.

## C.6 Summary

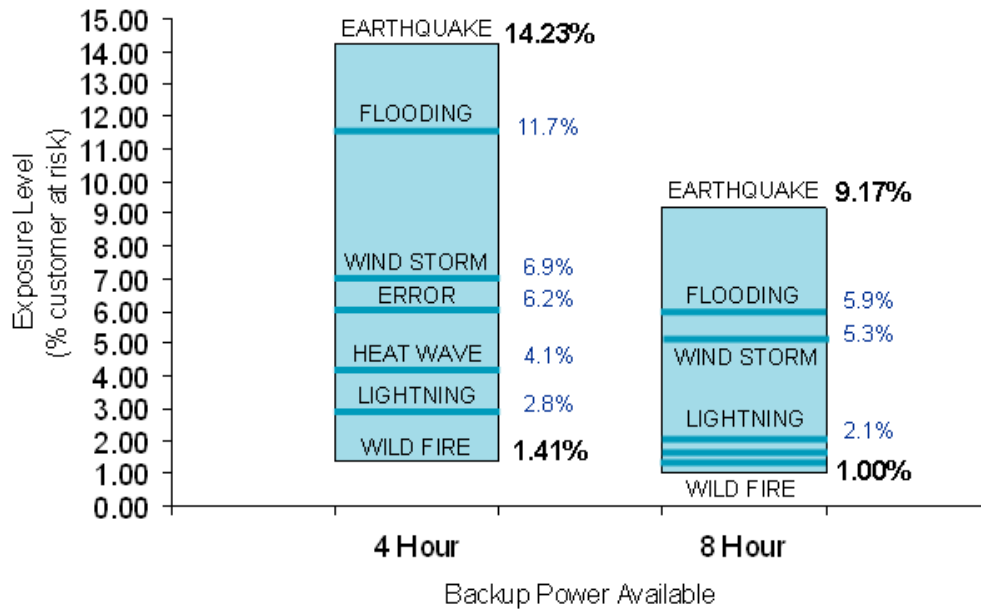
The basic conclusion is that the networks are well protected in design and architecture against the normal effects of power outages and normal natural disruptions to the power supply. Fiber rings and other network design features protect the functionality of the networks. To illustrate the scope of the problem and risks to telecommunications services to the broadband customers, we can use power outage data of previous events.

The difference between current architectures and the emerging and planned future broadband services lies chiefly with (i) the localized powering schemes at the customer premises, and (ii) the reduced ability to provide extended power backup at the customer sites.

The local powering of the customer premises will limit the telephony backup service to whatever battery reserve is provided in the gateway interface units which is currently cited as up to 8 hours of “talk time”. Having a CO with a full-running generator, as well as OSP nodes adequately supplied with additional batteries and portable generators will not extend the ability of the residential customer to make telephone calls after the battery in their broadband CPE is exhausted. Therefore, the power reserve at the customer premises becomes the determining factor for continuation of telecommunications services in these particular architectures.

Based on power outage data from previous reported events, one can estimate the percentage of customers served by FTTH broadband services that would be affected by a given event given 4 or 8 hours battery backup at the CPE equipment. This summary data is shown in the figure below where the fraction of customers that would experience an outage longer than 8 hours is in the range of 1.0% to 9.1%, with an average (across all the types of events listed before) of 3.9%. Subtracting the effect of the large impact of the earthquake event, the affected percentage of customers drops to only 2-3 %.



**Figure C-2. Backup Power at Customer Premises**

Apart from basic telephony service, the broadband CPE (Customer Premise Equipment) and services will not be supported for extended power outages by the present network architectures. That is, no CATV and PC Internet service should be expected, since customers are not expected or likely to have a UPS to run their CPE. In the future, customers may come to expect that all services (including Internet, CATV, video etc.) will remain operational during power disturbances. In such a case, a considerably larger power reserve will be required at the customer premise to meet such an expectation.

The use of wireless communications is an interim solution providing the cell towers and backhaul communications circuits are operating. If the utility power outage lasts longer, then the backup power (batteries) available at these cell towers will fail.

Current architectures cannot sustain normal telecommunications services during abnormal and massive events such as:

- A direct hit by a Katrina type hurricane on a major city
- A Richter level 9 or 9.5 earthquake in California
- A massive cyber-attack of the networks
- A nuclear event with associated HEMP (High Altitude Electromagnetic Pulse) effects.

The widespread and massive destructive nature of such incidents results in

the loss of many COs and multiple RT nodes. The result is that communications will be severely disrupted.

## C.7 NRIC Best Practices

### NRIC Best Practices: Numbering Format

Each NRIC Best Practice has a unique number that follows the numbering format:

**X - Y - Z ###**      Where:

**X** = the current, or most recent, NRIC Council

(e.g., 7 for NRIC-VII, which was chartered in 2004-05)

**Y** = the NRIC Council in which the Best Practice was last edited

(i.e., 7 for work revised within NRIC-VII)

**Z** = 0-to-4 for Network Reliability (including Disaster Recovery & Public Safety)

= 5 for Physical Security

= 8 for Cyber Security

**###** = may be digits so as to ensure that every Best Practice has a unique Z ### number.

### NRIC Power-Related Best Practices:

The first column (**Column A**) of the spreadsheet contains the NRIC Best Practice identifying number as given in [www.nric.org](http://www.nric.org).

**Column B** gives a summary description of the Best Practice.

**Column C** provides a source(s) for the recommendation as stated in [www.nric.org](http://www.nric.org).

**Note:** In the [www.nric.gov](http://www.nric.gov) website, 98 Best Practices are related to Power for all segments of the telecom industry (wireline, wireless, cable, satellite, and equipment providers). 52 of them (highlighted in yellow and blue colors in the CPUC corresponding spreadsheet) appear to be related to backup power systems. From those 52 Best Practices, 28 (highlighted in blue) appear to address generator deployment.

Table C-2 NRIC Best Practices – Power Related

| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>7-6-0761</u> | Network Operators and Service Providers should conduct periodic verification of the office synchronization plan and the diversity of timing links, power feeds and alarms.<br><b>Note:</b> Recommended by the NRSC Timing Outage Task Force Report - 2002                                                                                                                                            |
| <u>7-6-5131</u> | Network Operators should provide appropriate security for emergency mobile trailers (both pre- and post-deployment) in order to protect against a coordinated terrorist attack on emergency communications capabilities.                                                                                                                                                                             |
| <u>7-6-5133</u> | Network Operators should protect the identity of locations where emergency mobile trailers and equipment are stored.                                                                                                                                                                                                                                                                                 |
| <u>7-6-5210</u> | Network Operators, Service Providers and Property Managers should discourage use of Emergency Power Off (EPO) switches between the primary battery supplies and the main power distribution board. EPO switches are not recommended for use in traditional -48V DC battery plants.                                                                                                                   |
| <u>7-6-5231</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should develop documentation for the restoration of power for areas of critical infrastructure including such things as contact information, escalation procedures, restoration steps and alternate means of communication. This documentation should be maintained both on-site and at centralized control centers. |
| <u>7-7-0464</u> | Network Operators and local municipalities should cooperate on zoning issues that affect reliability of communication networks serving the public good (e.g., noise from emergency backup power generators, aesthetics of tower placement, public safety and health concerns).                                                                                                                       |
| <u>7-7-0492</u> | Network Operators should provide backup power (e.g., some combination of batteries, generator, fuel cells) at cell sites and remote equipment locations, consistent with the site specific constraints, criticality of the site, the expected load and reliability of primary power.                                                                                                                 |
| <u>7-7-0493</u> | Network Operators and Property Managers should consider placing fixed power generators at cell sites, where feasible.                                                                                                                                                                                                                                                                                |
| <u>7-7-0494</u> | Network Operators and Property Managers should consider including a provision in cell-site contracts for backup power.                                                                                                                                                                                                                                                                               |
| <u>7-7-0495</u> | Network Operators and Property Managers should consider pre-arranging contact information and access to restoral information with local power companies.                                                                                                                                                                                                                                             |
| <u>7-7-0496</u> | Network Operators and Property Managers should consider storing their portable generators at critical sites that are not otherwise equipped with stationary generators.                                                                                                                                                                                                                              |
| <u>7-7-0497</u> | Network Operators and Property Managers should consider connecting the power load to portable generators where they are stored and configuring them for auto-engage in the event of a failover.                                                                                                                                                                                                      |
| <u>7-7-0498</u> | Network Operators and Property Managers should consider alternative measures for cooling network equipment facilities (e.g., powering HVAC on generator, deploying mobile HVAC units) in a power outage event.                                                                                                                                                                                       |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>7-7-0499</u> | Network Operators and Service Providers should consider ensuring that the back-haul facility equipment located at the cell site is provided with backup power duration is equal to that provided for the other equipment at the cell site.                                                                                                                                                                                                                  |
| <u>7-7-0543</u> | Service Providers should establish agreements with Property Managers for both regular and emergency power.                                                                                                                                                                                                                                                                                                                                                  |
| <u>7-7-0549</u> | Network Operators should develop an engineering design for critical network elements and inter-office facilities that addresses diversity, and utilize management systems to provision, track and maintain that inter-office and intra-office diversity.                                                                                                                                                                                                    |
| <u>7-7-0622</u> | Network Operators, Service Providers, and Property Managers should use ANSI T1.311-1998 Standard for Telecommunications Environmental Protection, DC Power Systems for key equipment locations (e.g., routers, central office switches, and other critical network elements) to reduce fires associated with DC power equipment.<br><b>Note:</b> For ANSI T1.311 and other ATIS documents go to <a href="https://www.atis.org/">https://www.atis.org/</a> . |
| <u>7-7-0623</u> | Network Operators and Service Providers using Valve Regulated Lead Acid (VRLA) batteries should perform annual maintenance by performing a discharge test or by using an ohmic test instrument.<br><b>Note:</b> The aging properties of these batteries can lead to thermal runaway that may cause a fire.                                                                                                                                                  |
| <u>7-7-0624</u> | Network Operators, Service Providers, and Property Managers are encouraged to establish case history files, by equipment category for rectifiers, to facilitate decisions to replace such equipment with more efficient equipment based on failure trends.                                                                                                                                                                                                  |
| <u>7-7-0625</u> | Network Operators, Service Providers and Property Managers should consider placing electric utility transformers external to buildings.                                                                                                                                                                                                                                                                                                                     |
| <u>7-7-0627</u> | Network Operators, Service Providers and Property Managers should exercise, service, and calibrate AC circuit breakers per manufacturers' recommendations.                                                                                                                                                                                                                                                                                                  |
| <u>7-7-0634</u> | Network Operators, Service Providers and Property Managers together with the Power Company and other tenants in the location, should verify that aerial power lines are not in conflict with hazards that could produce a loss of service during high winds or icy conditions.                                                                                                                                                                              |
| <u>7-7-0635</u> | Network Operators, Service Providers, and Property Managers should ensure that AC surge protection is provided at the power service entrance to minimize the effects caused by lightning or extremely high voltages.                                                                                                                                                                                                                                        |
| <u>7-7-0644</u> | Network Operators, Service Providers, and Property Managers should use over-current protection devices and fusing.                                                                                                                                                                                                                                                                                                                                          |
| <u>7-7-0648</u> | Network Operators, Service Providers and Property Managers should ensure certified inspection of boilers & fuel storage units.                                                                                                                                                                                                                                                                                                                              |
| <u>7-7-0650</u> | Network Operators, Service Providers and Property Managers should place strong emphasis on human activities related to the operation of power systems (e.g., maintenance procedures, alarm system operation, response procedures, and training) for operations personnel.                                                                                                                                                                                   |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>7-7-0651</u> | Network Operators, Service Providers and Property Managers should consider providing diversity within power supply and distribution systems so that single point failures (SPOF) are not catastrophic. For large battery plants in critical offices, consider providing dual AC feeds (odd/even power service cabinets for rectifiers). Transfer switches should be listed to a UL standard for Transfer Switch Equipment. When transfer breaker systems are used, they must be mechanically and electrically interlocked. |
| <u>7-7-0652</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should adhere to the following applicable power engineering design standards; GR-513 (Power - LSSGR section 13), GR-63 (NEBS), GR-295 (Isolated Ground Planes), GR-1089 (Electromagnetic Compatibility), and ANSI T1.311 (DC power Systems).                                                                                                                                                                                               |
| <u>7-7-0653</u> | Network Operators, Service Providers and Property Managers should retain complete authority about when to transfer from the electric utility and operate standby generators.                                                                                                                                                                                                                                                                                                                                               |
| <u>7-7-0654</u> | Network Operators, Service Providers and Property Managers should not normally enter into power curtailment or load sharing contracts with electric utilities.                                                                                                                                                                                                                                                                                                                                                             |
| <u>7-7-0655</u> | Network Operators, Service Providers and Property Managers should coordinate hurricane and other disaster restoration work with electrical and other utilities as appropriate.                                                                                                                                                                                                                                                                                                                                             |
| <u>7-7-0656</u> | Network Operators and Service Providers should establish a general requirement for power conditioning, monitoring and protection for sensitive equipment.                                                                                                                                                                                                                                                                                                                                                                  |
| <u>7-7-0657</u> | Network Operators, Service Providers and Property Managers should design standby generator systems for fully automatic operation and for ease of manual operation, when required.                                                                                                                                                                                                                                                                                                                                          |
| <u>7-7-0658</u> | Network Operators, Service Providers and Property Managers should maintain adequate fuel on-site and have a well-defined re-supply plan. Generator life support systems (e.g., radiator fan, oil cooler fan, water transfer pumps, fuel pumps, engine start battery chargers) should be on the essential AC bus of the generator they serve.                                                                                                                                                                               |
| <u>7-7-0660</u> | Network Operators, Service Providers and Property Managers should have a plan that is periodically verified for providing portable generators to offices with and without stationary engines.                                                                                                                                                                                                                                                                                                                              |
| <u>7-7-0662</u> | Network Operators, Service Providers and Property Managers should exercise power generators on a routine schedule in accordance with manufacturer's specifications. For example, a monthly 1 hour engine run on load, and a 5 hour annual run.                                                                                                                                                                                                                                                                             |
| <u>7-7-0663</u> | Network Operators, Service Providers and Property Managers should coordinate scheduled power generator tests with all building occupants to avoid interruptions.                                                                                                                                                                                                                                                                                                                                                           |
| <u>7-7-0664</u> | Network Operators, Service Providers and Equipment Suppliers should provide indicating type control fuses on the front of the power panels, including smaller distribution panels.                                                                                                                                                                                                                                                                                                                                         |
| <u>7-7-0665</u> | Network Operators, Service Providers and Property Managers should provide and                                                                                                                                                                                                                                                                                                                                                                                                                                              |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | maintain accurate single line drawings of AC switch equipment on-site.                                                                                                                                                                                                                                                                                                                                                                |
| <u>7-7-0667</u> | Network Operators, Service Providers and Property Managers should keep circuit breaker racking/ratchet tools, spare fuses, fuse pullers, etc. readily available.                                                                                                                                                                                                                                                                      |
| <u>7-7-0668</u> | Network Operators, Service Providers and Equipment Suppliers and Property Managers should clearly label the equipment served by each circuit breaker and fuse.                                                                                                                                                                                                                                                                        |
| <u>7-7-0669</u> | Network Operators, Service Providers, and Property Managers should develop and/or provide appropriate emergency procedures for AC transfer.                                                                                                                                                                                                                                                                                           |
| <u>7-7-0671</u> | Network Operators, Service Providers and Property Managers should design and implement a preventive maintenance and inspection program for electrical systems.                                                                                                                                                                                                                                                                        |
| <u>7-7-0672</u> | Network Operators and Service Providers should provide a minimum of 3 hours battery reserve for central offices equipped with fully automatic standby systems.                                                                                                                                                                                                                                                                        |
| <u>7-7-0673</u> | Network Operators and Service Providers should provide temperature compensation on the rectifiers (or some method to detect/prevent thermal runaway), when valve regulated batteries are used.                                                                                                                                                                                                                                        |
| <u>7-7-0674</u> | Network Operators, Service Providers and Property Managers should initiate or continue a modernization program to ensure that outdated power equipment is phased out of plant. They should consider the capabilities of smart controllers, local and remote monitoring, and alarm systems when updating their power equipment. Power monitors and smart controllers should be integrated into engineering and operational strategies. |
| <u>7-7-0675</u> | Network Operators, Service Providers and Property Managers should, for new installations, consider using multiple small battery plants in place of single very large plants, and consider using multiple battery strings in each plant.                                                                                                                                                                                               |
| <u>7-7-0676</u> | Network Operators and Service Providers should not use low voltage disconnects or battery disconnects at central office battery plants.                                                                                                                                                                                                                                                                                               |
| <u>7-7-0677</u> | Network Operators, Service Providers and Property Managers should only use rectifier sequence controllers where necessary to limit load on the backup power generator.                                                                                                                                                                                                                                                                |
| <u>7-7-0679</u> | Network Operators, Service Providers and Equipment Suppliers should provide diverse power feeds for all redundant links (e.g., SS7, BITS clocks) and any components identified as critical single points of failure (SPOF) in transport and operations of the network.                                                                                                                                                                |
| <u>7-7-0680</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should provide protective covers on vulnerable circuit breakers which power critical equipment.                                                                                                                                                                                                                                                       |
| <u>7-7-0681</u> | Network Operators, Equipment Suppliers and Property Managers should ensure that fuses and breakers meet quality Level III reliability per Technical Reference (SR-332), Reliability Prediction Procedure for Electronic Equipment.                                                                                                                                                                                                    |
| <u>7-7-0682</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers                                                                                                                                                                                                                                                                                                                                                       |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                       |
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|                 | should ensure that power wire, cable, and signaling cables used in communications locations meet NEBS.                                                                                                                                                                                                                                                                                                                                            |
| <u>7-7-0683</u> | Network Operators, Service Providers and Equipment Suppliers should not mix DC power cables, AC power cables and telecommunications cables wherever possible.                                                                                                                                                                                                                                                                                     |
| <u>7-7-0684</u> | Network Operators, Service Providers and Property Managers should verify DC fusing levels throughout the power supply and distribution system, especially at the main primary distribution board, to ensure that fuses and breakers are not loaded at more than 80% of their rated ampacity. Diode arrangements require additional special overcurrent protection considerations. In addition, protector size should never exceed cable ampacity. |
| <u>7-7-0685</u> | Network Operators should have detailed methods and procedures to identify protection required around energized DC buses.                                                                                                                                                                                                                                                                                                                          |
| <u>7-7-0689</u> | Network Operators and Service Providers should provide a separate battery discharge alarm for all critical infrastructure facilities, and where feasible, periodically (e.g., every 15 minutes) repeat the alarm as long as the condition exists.                                                                                                                                                                                                 |
| <u>7-7-0690</u> | Network Operators and Property Managers should consider providing power alarm redundancy so that no single point alarm system failure will lead to a network power outage.                                                                                                                                                                                                                                                                        |
| <u>7-7-0692</u> | Network Operators, Service Providers and Equipment Suppliers should consider using fail-safe, normally closed contacts that open for an alarm, for critical alarms produced by single contacts (one on one).                                                                                                                                                                                                                                      |
| <u>7-7-0693</u> | Network Operators, Service Providers and Property Managers should emphasize the use of Methods Of Procedures (MOPs), vendor monitoring, and performing work on in-service equipment during low traffic periods.                                                                                                                                                                                                                                   |
| <u>7-7-0694</u> | Network Operators and Service Providers should check for current flow in cables with AC/DC clamp-on ammeters before removing the associated fuses or opening the circuits during removal projects.                                                                                                                                                                                                                                                |
| <u>7-7-0695</u> | Network Operators, Service Providers and Property Managers should develop and test plans to address situations where normal power backup does not work (e.g., commercial AC power fails, the standby generator fails to start, automatic transfer switch fails).                                                                                                                                                                                  |
| <u>7-7-0696</u> | Network Operators, Service Providers and Property Managers should use infrared thermography to check power connections and cabling in central offices when trouble shooting, during installation test and acceptance, and every 5 years.                                                                                                                                                                                                          |
| <u>7-7-0697</u> | Network Operators, Service Providers and Equipment Suppliers should employ an Ask                                                                                                                                                                                                                                                                                                                                                                 |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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|                 | <p>Yourself program as part of core training and daily operations. This initiative is intended to reinforce the responsibility every employee has to ensure flawless network service. (See Reference/Comments for additional details).</p> <p><b>Note:</b> Employees should stop and resolve problems when they can't answer yes to any of the following questions:</p> <ul style="list-style-type: none"> <li>• Do I know why I'm doing this work?</li> <li>• Have I identified and notified everybody who will be directly affected by this work?</li> <li>• Can I prevent or control a service interruption?</li> <li>• Is this the right time to do this work?</li> <li>• Am I trained and qualified to do this work?</li> <li>• Are work orders, MOPs, and supporting documentation current and error-free?</li> <li>• Do I have everything I need to quickly restore service if something goes wrong?</li> <li>• Have I walked through the procedure?</li> </ul> |
| <u>7-7-0699</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should design standby systems (e.g., power) to withstand harsh environmental conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <u>7-7-0700</u> | Network Operators, Service Providers and Equipment Suppliers should consider the need for power expertise/power teams.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <u>7-7-0701</u> | Network Operators, Service Providers and Property Managers should provide security for portable generators.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <u>7-7-0702</u> | Network Operators and Service Providers should minimize dependence on equipment requiring AC power feeds in favor of DC-powered components.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <u>7-7-0703</u> | Network Operators and Service Providers and Property Managers should secure remote power maintenance systems to prevent unauthorized use.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <u>7-7-0760</u> | <p>Network Operators and Service Providers should maintain records that accurately track the diversity of internal wiring for office synchronization, including timing leads and power.</p> <p><b>Note:</b> Recommended by the NRSC Timing Outage Task Force Report - 2002</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <u>7-7-0773</u> | Network Operators, Service Providers and Property Managers should perform annual capacity evaluation of power equipment, and perform periodic scheduled maintenance, including power alarm testing.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <u>7-7-0774</u> | Network Operators, Service Providers and Equipment Suppliers should provide warning signs to indicate precautions to be taken when powering on circuits that require special procedures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <u>7-7-0819</u> | For the deployment of Residential Internet Access Service, Network Operators should provide backup power for broadband network equipment when economically and technically practical.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <u>7-7-1028</u> | Network Operators, Service Providers and Property Managers should engage in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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|                 | preventative maintenance programs for network site support systems including emergency power generators, UPS, DC plant (including batteries), HVAC units, and fire suppression systems.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <u>7-7-1029</u> | Network Operators and Service Providers should periodically review their portable power generator needs to address changes to the business.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <u>7-7-1033</u> | Network Operators should develop a strategy for deployment of emergency mobile assets such as Cell on Wheels (COWs), cellular repeaters, Switch on Wheels (SOWs), transportable satellite terminals, microwave equipment, power generators, HVAC units, etc. for emergency use or service augmentation for planned events (e.g., National Special Security Event (NSSE)).                                                                                                                                                                                                                                                                                                                           |
| <u>7-7-1067</u> | Network Operators, Service Providers and Property Managers should consider, in preparation for predicted natural events, placing standby generators on line and verifying proper operation of all subsystems (e.g., ice, snow, flood, hurricanes).                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <u>7-7-5041</u> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should establish and implement policies and procedures to secure and restrict access to power, environmental, security, and fire protection systems.<br><b>Note:</b> Examples of power and environmental systems: HVAC, standby emergency power, generators, UPS.                                                                                                                                                                                                                                                                                                                                                   |
| <u>7-7-5042</u> | Network Operators, Service Providers and Property Managers should establish and implement policies and procedures to secure and restrict access to fuel supplies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <u>7-7-5058</u> | <b>Back-up Power:</b> Network Operators, Service Providers, Equipment Suppliers and Property Managers should ensure that all critical infrastructure facilities, including the security equipment, devices and appliances protecting it, are supported by backup power systems (e.g., batteries, generators, fuel cells).<br><b>Note:</b> Some local regulations and building codes may influence the options available.                                                                                                                                                                                                                                                                            |
| <u>7-7-5076</u> | Network Operators and Service Providers should ensure and periodically review intra-office diversity of critical resources including power, timing source and signaling leads (e.g., SS7).<br><b>Note:</b> SS7 refers to the Signaling System 7. An example of diversity would be where CCS links traverse D4 channels banks, the D4 channel bank are often shelves in bays. The first level of diversity is that the CCS links are on different interfaces to different D4 channel banks, the channel banks aggregate link (DS-1) connects to diverse M13 multiplexes or DCS frames, continuing through the multiplexing levels across diverse transport paths. This could be called NE diversity. |
| <u>7-7-5197</u> | Network Operators, Service Providers, and Property Managers should periodically inspect, or test as appropriate, the grounding systems in critical network facilities.<br><b>Note:</b> For network telecom inspection and test guidance see related documents such as the NRIC BP 0636 (verify grounding arrangements), GR-1089, <i>Telcordia Electromagnetic Compatibility and Electrical Safety - Generic Criteria Equipment</i> , and National Electric Code, NEC                                                                                                                                                                                                                                |
| <u>7-7-5203</u> | Network Operators, Service Providers, and Property Managers should develop,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

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| NRIC Number                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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|                                 | maintain and administer a comprehensive program to sustain a reliable power infrastructure.                                                                                                                                                                                                                                                                                                                                                                |
| <a href="#"><u>7-7-5204</u></a> | Service Providers, Network Operators and Property Managers should ensure availability of emergency/backup power (e.g., batteries, generators, fuel cells) to maintain critical communications services during times of commercial power failures, including natural and manmade occurrences (e.g., earthquakes, floods, fires, power brown/black outs, terrorism). The emergency/backup power generators should be located onsite, where appropriate.      |
| <a href="#"><u>7-7-5206</u></a> | Network Operators, Service Providers and Property Managers should maintain sufficient fuel supplies for emergency/backup power generators running at full load to allow for contracted refueling.<br>Also see NRIC BP 0658                                                                                                                                                                                                                                 |
| <a href="#"><u>7-7-5207</u></a> | Network Operators, Service Providers and Property Managers should take appropriate precautions to ensure that fuel supplies and alternate sources of power are available for critical installations in the event of major disruptions in a geographic area (e.g., hurricane, earthquake, pipeline disruption). Consider contingency contracts in advance with clear terms and conditions (e.g., Delivery time commitments, T&Cs).<br>Also see NRIC BP 0658 |
| <a href="#"><u>7-7-5208</u></a> | Network Operators, Service Providers, Equipment Suppliers and Property Managers should ensure that electrical work (e.g., AC and high current DC power distribution) is performed by qualified technicians.                                                                                                                                                                                                                                                |
| <a href="#"><u>7-7-5209</u></a> | Network Operators, Service Providers and Property Managers should restrict access to the AC transfer switch housing area, ensure that scheduled maintenance of the transfer switch is performed, and ensure that spare parts are available.                                                                                                                                                                                                                |
| <a href="#"><u>7-7-5211</u></a> | Network Operators, Service Providers and Property Managers should disable power equipment features that allow switching off of power equipment from a remote location (i.e. dial up modem). During severe service conditions, such features may be activated to allow a degree of remote control.                                                                                                                                                          |
| <a href="#"><u>7-7-5212</u></a> | Network Operators, Service Providers and Property Managers should consider placing generator sets and fuel supplies at critical sites within a secured area to prevent unauthorized access, reduce the likelihood of damage and/or theft, and to provide protection from explosions and weather.                                                                                                                                                           |
| <a href="#"><u>7-7-5213</u></a> | Network Operators, Service Providers and Property Managers should, where feasible, place fuel tanks in a secured and protected area. Access to fill pipes, fuel lines, vents, manways, etc. should be restricted (e.g., containment by fencing, walls, buildings, buried) to reduce the possibility of unauthorized access.                                                                                                                                |
| <a href="#"><u>7-7-5214</u></a> | Network Operators, Service Providers and Property Managers should consider placing all power and network equipment in a location to increase reliability in case of disaster (e.g., floods, broken water mains, fuel spillage). In storm surge areas, consider placing all power related equipment above the highest predicted or recorded storm surge levels.                                                                                             |
| <a href="#"><u>7-7-5216</u></a> | Network Operators, Service Providers and Property Managers should consider                                                                                                                                                                                                                                                                                                                                                                                 |

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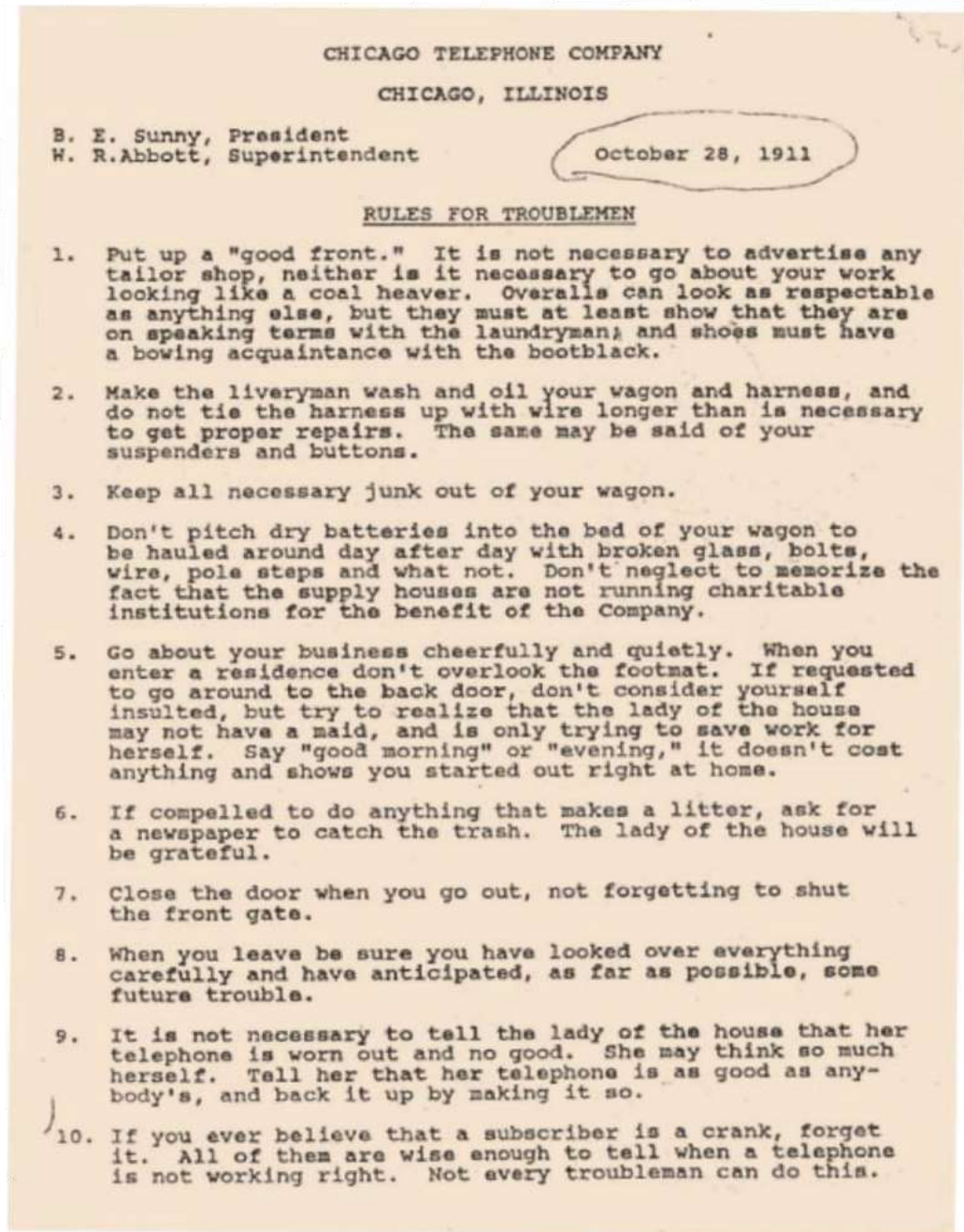
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| NRIC Number     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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|                 | providing secure pre-constructed exterior wall pathways for mobile generator connections or tap box connections.                                                                                                                                                                                                                                                                                                                                                                                |
| <u>7-7-5229</u> | Network Operators, Service Providers and Property Managers should have controlled access to comprehensive facility cabling documentation (e.g., equipment installation plans, network connections, power, grounding and bonding) and keep a backup copy of this documentation at a secured off-site location.                                                                                                                                                                                   |
| <u>7-7-5232</u> | Network Operators, Service Providers, and Property Managers should test fuel reserves used for standby or backup power for contamination at least once a year or after any event (e.g., earth tremor, flood) that could compromise the integrity of the tank housing, fill pipe or supply pipe.<br><b>Note:</b> These tests should include inspection for water, sediment, organic contaminants, and any other items that may inhibit the peak performance of the standby/backup generator.     |
| <u>7-7-5241</u> | Network Operators, Service Providers and Equipment Suppliers should consider placing access and facility alarm points to critical or sensitive areas on backup power.                                                                                                                                                                                                                                                                                                                           |
| <u>7-7-5275</u> | Network Operators, Service Providers and Equipment Suppliers should consider backup power capabilities for Command and Control (Crisis Teams) so that communications and access to critical systems can be maintained in the event of a significant disruption to commercial power.<br><b>Note:</b> This could include, but is not limited to, moving crisis team personnel to locations where there exists long-term power backup, installing generator backup at certain critical sites, etc. |
| <u>7-7-5281</u> | Network Operators, Service Providers and Property Managers with buildings serviced by more than one emergency generator, should design, install and maintain each generator as a stand-alone unit that is not dependent on the operation of another generator for proper functioning, including fuel supply path.                                                                                                                                                                               |

## C.8 Historical Work Rules

The following *Rules for Troublemens* from the *Chicago Telephone Company* in 1911 are over 100 years old, but still contain the service principles and desire for completing a quality job for achieving a satisfied customer that is important for today's and tomorrow's networks.

**Figure C-3 A 1911 Rules For Troublemens - Chicago Telephone Company**



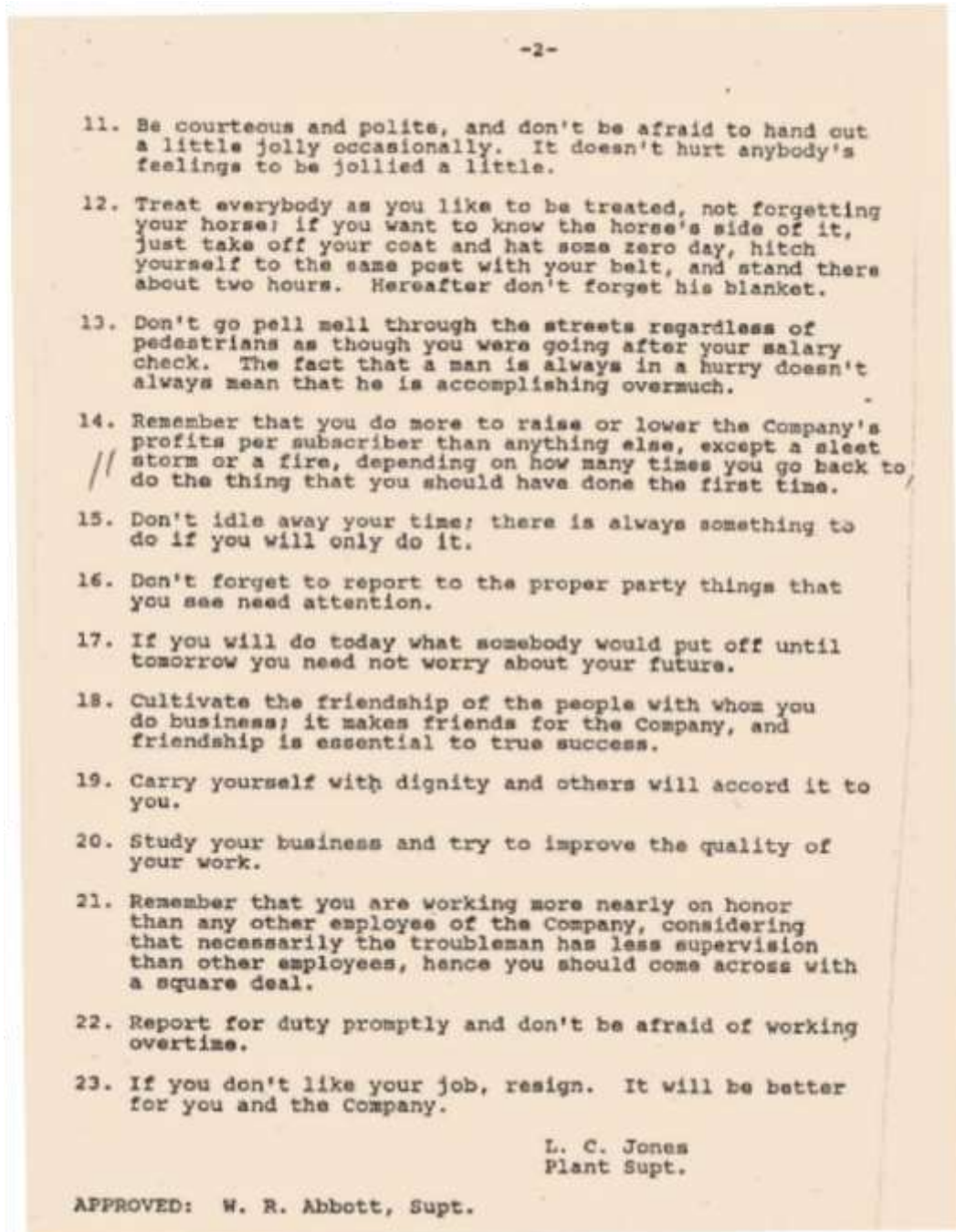
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C-50

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**Figure C-3 B 1911 Rules For Troublemens - Chicago Telephone Company**

## Appendix D: References

All documents are subject to change, and their citations in this document reflect the most current information available at the time of this printing. Readers are advised to check the current status and availability of all documents.

**Note:** When a specific document or standard is referenced in this GR, the latest issue is to be used.

### D.1 GR Documents

1. GR-20-CORE, *Generic Requirements for Optical Fiber and Optical Fiber Cable*.
2. GR-26-CORE, *Generic Requirements for Controlled Environmental Vaults (CEVs)*.
3. GR-43-CORE, *Generic Requirements for Telecommunications Huts*.
4. GR-49-CORE, *Generic Requirements for Outdoor Telecommunication Network Interface Devices (NIDs)*.
5. GR-60-CORE, *Generic Requirements for Wooden Utility Poles*.
6. GR-63-CORE, *NEBS™ Requirements: Physical Protection*.
7. GR-180-CORE, *Generic Requirements for Hardware Attachments for Steel, Concrete, and Fiberglass Poles* (superseded by GR-3174).
8. GR-326-CORE, *Generic Requirements for Single-Mode Optical Connectors and Jumper Assemblies*.
9. GR-356-CORE, *Generic Requirements for Optical Cable Innerduct, Associated Conduit, and Accessories*.
10. GR-409-CORE, *Generic Requirements for Indoor Optical Fiber Cable*.
11. GR-421-CORE, *Generic Requirements for Metallic Telecommunications Cable*.
12. GR-487-CORE, *Telcordia Generic Requirements for Electronic Equipment Cabinets*.
13. GR-771-CORE, *Generic Requirements for Optical Fiber Splice Closures*.
14. GR-902-CORE, *Generic Requirements for Handholes and Other Below-Ground Splice Vaults*.
15. GR-950-CORE, *Telcordia Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems*.
16. GR-1089-CORE, *Telcordia Electromagnetic Compatibility (EMC) and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*.
17. GR-1275-CORE, *Central Office/Network Environment Equipment*

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*Installation/ Removal Generic Requirements.*

18. GR-2836-CORE, *Generic Requirements for Assuring Corrosion Resistance of Telecommunication Equipment in the Outside Plant.*
19. GR-2847-CORE, *Generic Requirements for Cable Penetration Seal Assembly for CEVs and Manholes.*
20. GR-3031-CORE, *Generic Requirements for Indoor Electronic Equipment Cabinets.*
21. GR-3032-CORE, *Interactions Between Generic Requirements Documents GR-3108, GR-487, and GR-950.*
22. GR-3033-CORE, *Generic Requirements for Indoor and Outdoor Battery Backup Cabinets.*
23. GR-3108-CORE, *Telcordia Generic Requirements for Network Equipment in the Outside Plant (OSP).*
24. GR-3155-CORE, *Generic Requirements for Single/Bundled Microducts and In-Living Unit (ILU) Cable Pathways.*
25. GR-3159-CORE, *Generic Requirements for Fiber-Reinforced Composite (FRC), Concrete, and Steel Utility Poles.*
26. GR-3163-CORE, *Generic Requirements for Metallic Telecommunications Service and Distribution Drop Wires.*
27. GR-3171-CORE, *Generic Requirements for Network Elements Used in Wireless Networks Physical Layer Criteria.*
28. GR-3174-CORE, *Generic Requirements for Hardware Attachments for Utility Poles.*
29. GR-3178-CORE, *Generic Requirements for Wireless Transceiver Facilities (Active Antennas, Distributed Antenna Systems [DAS], Free-Space Optics [FSOs], Remote Radio Heads [RRHs], and Small Cells).*
30. MDP-326-175, *Steel Wire Strand Specification*, June 1982 (replaced PUB 55010).
31. SR-2868, *Right-of-Way Manual.*
32. SR-3650, *Structures Negotiation Manual.*
33. TR-NWT-000354, *Generic Requirements for Re-enterable Encapsulants.*
34. Telcordia (Bellcore) CA0-8546, *B, C, and D Plastic Conduit.*
35. Telcordia (Bellcore) Practice BR-081-710-200, *Insulating Gloves, Leather Protectors, Fabric Liners, and Glove Bag - Description and Use.*
36. Telcordia (Bellcore) Practice BR-621-415-220, *Toggle Anchor Guying System.*
37. Telcordia (Bellcore) Practice BR-627-020-005, *Bonding and Grounding - Aerial Plant (Metallic Conduit and Optical Fiber Cable) - General* (1986).

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38. Telcordia (Bellcore) Practice BR-627-210-018, *Suspension Strand - Tension and Sags: Copper Conductor Cables*.
39. Telcordia (Bellcore) Practice BR-627-610-205, *Block and Building Cable Placing* (Issue 3, 1990).
40. Telcordia (Bellcore) Practice BR-629-100-010, *Buried Plant: Precautions and Maintenance in Existing Systems* (Issue 3, 1993).
41. Telcordia (Bellcore) Practice BR-629-300-215, *Buried Plant - Plowing* (Issue 3, 1984).
42. Telcordia (Bellcore) Practice BR-638-200-015, *Buried Cable Shield Continuity - Joint Buried Plant* (1987).
43. Telcordia (Bellcore) Practice BR-877-302-100, *Corrosion Control of Grounding Electrodes at Remote Electronic Sites*.
44. Telcordia (Bellcore) Practice, BR-917-356-101, *Buried Cable Systems - Joint Random Separation* (Issue 3, 1991).
45. Telcordia BSP Practice BSP-620-150-010, *Manhole Covers - Removing and Placing*.
46. Telcordia BSP Practice BSP-627-200-015, *Suspension Strand Selection - Copper Conductor Cables in All Loading Areas*.
47. Telcordia BSP Practice BSP-877-115-100, *Corrosion Practices, Application of Insulating Joints in Telephone Plant*.
48. Telcordia BSP Practice BSP-919-240-300, *Underground Conduit Manholes*.

## D.2 Non-GR Documents

49. AASHTO specifications, *A Policy on Accommodation of Utilities within Freeway Right-of-Way*.
50. AASHTO specifications, *Standard Specifications for Highway Bridges – H-10 and H-20 ratings*.
51. ACI 318, *Building Code Requirements for Reinforced Concrete*, American Concrete Institute.
52. American Wood Protection Association (AWPA) - Book of Standards:
  - U-Documents: User Specification for Treated Wood
  - T-Documents: Processing and Treatment Standard
  - P-Documents: Preservative/Protectant Standards for Preservative Solutions
  - A-Documents: Analysis Method Standards
  - E-Documents: Evaluation Standards
  - M-Documents: M13 - *Guidelines for a Pole Maintenance Program*.
53. ANSI C135, *American National Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction*, 1998. Also see Revision 1.
54. ANSI C136, *American National Standard for Roadway and Area Lighting*.

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55. ANSI C136.20, *American National Standard for Roadway Lighting Equipment – Fiber-Reinforced Plastic (FRP) Lighting Poles*.
56. ANSI O5 Standards:
  - ANSI O5.1, *Wood Poles - Specifications and Dimensions*, 2008
  - ANSI O5.2, *Structural Glued Laminated Timber for Utility Structures*.
  - ANSI O5.3, *Wood Products - Solid Sawn Wood Crossarms and Braces - Specifications and Dimensions*, 2008.
  - ANSI O5.4, *Naturally-Durable Hardwood Poles - Specifications and Dimensions*.
  - ANSI O5.6, *Solid Sawn-Naturally Durable Hardwood Crossarms & Braces - Specifications and Dimensions*.
57. ANSI Y32.2, *Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Class Designation Letters)*.
58. ANSI Z136 (see various revisions through 2008):
  - ANSI Z136.1, *Safe Use of Lasers*, 2007.
  - ANSI Z136.2, *Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources*.
59. ANSI/EIA/TIA-590, *Standard for Physical Location and Protection of Below-Ground Optical Fiber Cable Plant*, 1997.
60. ANSI/NEMA C29.1, *Electrical Power Insulators – Test Methods*
61. ANSI/NEMA C29.11, *Composite Insulators – Test Methods*.
62. ANSI/NEMA GR 1, *Grounding Rod Electrodes and Grounding Rod Electrode Couplings*, 2007.
63. ANSI/NEMA Z535.1-2006, *Safety Colors* (ANSI Z53.1-1979, *American National Standard Safety Color Code for Marking Physical Hazards*, was updated and combined into this standard in 1979).
64. ANSI/NEMA Z535.2-2011, *American National Standard for Environmental and Facility Safety Signs*.
65. ANSI/SCTE-77, *Specification for Underground Enclosure Integrity*.
66. APWA - Utility Location and Coordination Council's (ULCC) *Uniform Color Code*, American Public Works Association.
67. ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, 2010 (replaces the 1998, 2002, and 2005 ASCE standards).
68. ASCE-48, *Design of Steel Transmission Pole Structures*.
69. ASCE-74, *Guidelines for Electrical Transmission Line Structural Loading*, Third Edition, 2009.
70. ASCE-104, *Recommended Practice for Fiber-Reinforced Composite*

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*Products for Overhead Utility Line Structures.*

71. ASCE-111, *Reliability-Based Design of Utility Pole Structures*, 2006.
72. ASCE 118, *Below-Ground Pipeline Networks for Utility Cables*.
73. ASTM A90, *Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*, 2009.
74. ASTM A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*, 2009.
75. ASTM A363-03, *Standard Specification for Zinc-Coated (Galvanized) Steel Overhead Ground Wire Strand*, 2009.
76. ASTM A475-03, *Standard Specification for Zinc-Coated Steel Wire Strand*, 2009.
77. ASTM A855-03, *Standard Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Wire Strand*, 2009.
78. ASTM B117-16, *Standard Practice for Operating Salt Spray (Fog) Apparatus*.
79. ASTM C478-15a, *Standard Specification for Circular Precast Reinforced Concrete Manhole Sections*.
80. ASTM C497-16a, *Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile*.
81. ASTM C857-16, *Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures*.
82. ASTM C858-10e1, *Standard Specification for Underground Precast Concrete Utility Structures*.
83. ASTM C891-11, *Standard Practice for Installation of Underground Precast Concrete Utility Structures*.
84. ASTM C923-08, *Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals*.
85. ASTM C990-09, *Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants*.
86. ASTM C1037-16, *Standard Practice for Inspection of Underground Precast Concrete Utility Structures*.
87. ASTM D120-14a, *Standard Specification for Rubber Insulating Gloves*.
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### D.3 To Obtain Additional Reference Materials

|                                                           |                                                                   |
|-----------------------------------------------------------|-------------------------------------------------------------------|
| Alliance for Telecommunications Industry Solutions (ATIS) | <a href="http://www.atis.org/">http://www.atis.org/</a>           |
| American National Standards Institute (ANSI)              | <a href="http://web.ansi.org/">http://web.ansi.org/</a>           |
| American Society for Testing and Materials (ASTM)         | <a href="http://www.astm.com/">http://www.astm.com/</a>           |
| American Society of Civil Engineers (ASCE)                | <a href="http://www.asce.org/">http://www.asce.org/</a>           |
| American Public Works Association (APWA)                  | <a href="http://www.apwa.net">http://www.apwa.net</a>             |
| Electronic Industries Alliance (EIA)                      | <a href="http://www.eia.org/">http://www.eia.org/</a>             |
| Federal Communications Commission (FCC)                   | <a href="http://www.fcc.gov/">http://www.fcc.gov/</a>             |
| Institute of Electrical and Electronics Engineers (IEEE)  | <a href="http://ieee.org/">http://ieee.org/</a>                   |
| International Electrotechnical Commission (IEC)           | <a href="http://www.iec.ch/">http://www.iec.ch/</a>               |
| International Organization for Standardization (ISO)      | <a href="http://www.iso.org/">http://www.iso.org/</a>             |
| National Fire Protection Association (NFPA)               | <a href="http://www.nfpa.org/">http://www.nfpa.org/</a>           |
| Occupational Safety and Health Administration (OSHA)      | <a href="http://www.osha.gov/">http://www.osha.gov/</a>           |
| Telecommunications Industry Association (TIA)             | <a href="http://www.tiaonline.org/">http://www.tiaonline.org/</a> |
| Underwriters Laboratories (UL)                            | <a href="http://www.ul.com/">http://www.ul.com/</a>               |

### D.4 Family of Requirements (FR) and Family of Documents (FD) Sets

Several legacy documents have been combined into FD/FR sets, as listed below. The GR and SR documents included in these sets can also be ordered individually from the [GR Website](#).

|                    |                                                                                                         |
|--------------------|---------------------------------------------------------------------------------------------------------|
| FD-ARPP-01         | <i>Automated Reliability Prediction Procedure</i>                                                       |
| FD-NEBS-01         | <i>NEBS<sup>TM</sup> Physical and Electrical Protection</i>                                             |
| FR-INSTALL-19      | <i>Central Office/Network Environment Installation and Detail Engineering Requirements and Services</i> |
| FR-PASSIVE-COMP-01 | <i>Generic Requirements and Reliability for Passive Optical Components</i>                              |



## D.5 Reference Notes

All documents are subject to change, and their citations in this document reflect the most current information available at the time of this printing. Readers are advised to check the current status and availability of all documents.

## Appendix E: Glossary

**AASHTO** — American Association of State Highway and Transportation Officials

**AC** — Alternating Current

**ACI** — American Concrete Institute

**ADSS** — All-Dielectric Self-Support

**ADT** — Average Daily Traffic

**AHJ** — Authority Having Jurisdiction

**ALPETH** — Aluminum Polyethylene

**APWA** — American Public Works Association

**ASCE** — American Society of Civil Engineers

**ANSI** — American National Standards Institute

**ASTM** — American Society for Testing and Materials

**ATIS** — Alliance for Telecommunications Industry Solutions

**AWG** — American Wire Gauge

**AWPA** — American Wood Protection Association

**B&G** — Bonding and Grounding

**BBU** — Battery Backup Unit

**BET** — Building Entrance Terminal

**BDN** — Buried Duct Networks

**BIF** — Bend Insensitive Fiber

**BPL** — Broadband over Power Line

**BRF** — Bend Resistant Fiber **CAD** — Computer-Aided Design

**CATV** — Cable Television

**CEF** — Cable Entrance Facility

**CEV** — Controlled Environmental Vault

**CFM** — Cubic Feet per Minute

**CFR** — Code of Federal Regulations

**CGA** — Common Ground Alliance

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**CLEC** — Competitive Local Exchange Carriers

**CMP** — Code-Making Panels

**CO** — Central Office

**CoF** — Coefficient of Friction

**CP** — Change Proposal

**CPE** — Customer Premises Equipment

**CR** — Corrosion Resistant

**CSA** — Canadian Standards Association; CSA Group

**CWSZ** — Communications Workers Safety Zone

**DAS** — Distributed Antenna System

**DC** — Direct Current

**DHS** — Department of Homeland Security

**DoD** — Department of Defense

**DOT** — Department of Transportation

**EHS** — Extra High Strength

**EL** — Enterprise License

**EMC** — Electromagnetic Compatibility

**EMD** — Electromagnetic Detection

**EMI** — Electromagnetic Interference

**EPA** — Environmental Protection Agency

**ERP** — Effective Radiated Power

**ESD** — Electrostatic Discharge

**FCC** — Federal Communications Commission

**FDA** — Fiber Distribution Area

**FDH** — Fiber Distribution Hub

**FHA** — Federal Housing Authority

**FITL** — Fiber-In-The-Loop

**FITS** — Factory Installed Termination System

**FR** — Family of Requirements

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**FRC** — Fiber-Reinforced Composite

**FRP** — Fiber-Reinforced Polymer

**FTTA** — Fiber-To-The-Antenna

**FTTC** — Fiber-To-The-Curb

**FTTH** — Fiber-To-The-Home

**FTTN** — Fiber-To-The-Node

**FTTP** — Fiber-To-The-Premises

**FTTx** — Fiber-To-The-X

**GEC** — Grounding Electrode Conductor

**GID** — Graphic and Interactive Design

**GPR** — Ground Penetrating Radar

**GPS** — Global Positioning System

**GR** — Generic Requirements document

**HASB** — High-Air-Speed, Blown Cable

**HDD** — Horizontal Directional Drilling

**HDPE** — High-Density PolyEthylene

**HDSL** — High-bit-rate Digital Subscriber Line

**HFC** — Hybrid Fiber Coaxial

**HS** — High Strength

**HVAC** — Heating, Ventilation and Air Conditioning

**IBT** — Intersystem Bonding Termination

**ICEP** — Inductive Coordination and Electrical Protection

**ICES** — International Committee on Electrical Safety

**ID** — Inside Diameter

**IEC** — International Electrotechnical Commission

**IEEE** — Institute of Electronics and Electrical Engineers

**ILEC** — Independent Local Exchange Carrier

**ILR** — Issues List Report

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**ILU** — In-Living Unit

**IMC** — Intermediate Metal Conduit

**IoT** — Internet of Things

**ISO** — International Standards Organization

**JUA** — Joint-Use Agreement

**LEC** — Local Exchange Carrier

**LED** — Light-Emitting Diode

**LEL** — Lower Explosive Limit

**M&P** — Methods and Procedures

**MAD** — Minimum Approach Distance

**MDU** — Multiple Dwelling Unit

**MGN** — Multi-Grounded Neutral

**MOOC** — Massive Open Online Courses

**MPE** — Maximum Permissible

**MSC** — Mobile Switching Center

**NACE** — National Association of Corrosion Engineers

**NCRP** — National Council on Radiation Protections and Measurements

**NEBS** — Network Equipment-Building System

**NEC** — National Electrical Code

**NEETRAC** — National Electric Energy Testing Research and Applications Center

**NEMA** — National Electrical Manufacturers Association

**NESC** — National Electrical Safety Code

**NFPA** — National Fire Protection Association

**NID** — Network Interface Device

**NIS** — Network Infrastructure Solutions

**NOC** — Network Operations Control

**NPDES** — National Pollution Discharge Elimination System

**OD** — Outside Diameter

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**OFCS** — Optical Fiber Communications System

**ONT** — Optical Network Terminal

**ONU** — Optical Network Unit

**OPGW** — Optical Ground Wire

**OPSU** — ONT Power Supply Unit

**OSHA** — Occupational Safety and Health Administration

**OSP** — Outside Plant

**OTDR** — Optical Time Domain Reflectometer

**PC** — Polymer Concrete

**PEL** — Permissible Exposure Level

**PGE** — Primary Grounding Electrode

**PGEC** — Primary Grounding Electrode Conductor

**PMD** — Polarization Mode Dispersion

**PoE** — Power over Ethernet

**PON** — Passive Optical Network

**PPE** — Personal Protection Equipment

**PPI** — Plastics Pipe Institute

**ppm** — parts per million

**PSTN** — Public Switched Telephone Network

**PUC** — Public Utility Commission

**PV** — Photovoltaic

**PVC** — PolyVinyl Chloride

**QMS** — Quality Management System

**RF** — Radio Frequency

**RFE** — Radio Frequency Energy

**RFSP** — Radio Frequency Safety Program

**RMC** — Rigid Metal Conduit

**ROW** — Right-of-Way

**RTV** — Room Temperature Vulcanization

**SC** — Subcommittee

**SCTE** — Society of Cable Telecommunications Engineers

**SDR** — Standard Dimension Ratio

**SR** — Special Report

**STALPETH** — Sheathed Aluminum Polyethylene

**SUE** — Subsurface Utility Engineering

**TLV** — Threshold Limit Value

**TR** — Technical Reference

**TWA** — Time-Weighted Average

**UL** — Underwriters Laboratory

**UV** — Ultraviolet

**VRAD** — Video Ready Access Device

**WG** — Working Group

**WiTF** — Wireless Transceiver Facility

**WTB** — Wireless Telecommunications Bureau



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**Foreign Tax Payment.** For a Licensee which is not a United States corporation, Ericsson will not accept remittance of less than the full amount payable by Licensee unless:

- a. Licensee withholds that amount to satisfy tax withholding requirements imposed by the country (other than the United States) in which Licensee resides or in which Licensee has accepted delivery of the Licensed Product; and
- b. Licensee furnishes a receipt issued by the withholding tax jurisdiction and certifying deposit of the withheld amount into its treasury or other tax depository to Ericsson's sole credit, or a certification on Licensee's stationery that Licensee has deposited the withheld amount into its tax jurisdiction's treasury or other tax depository to Ericsson's sole credit.

Further, to ensure the orderly processing of Ericsson tax returns, Licensee shall provide to Ericsson a summary of all amounts withheld during the year no later than ten business days after December 31 of each year addressed to Ericsson Inc., 6300 Legacy Dr., Plano, Texas 75024, Attn: Tax Management Department.

**Governing Law.** This Agreement is a contract between Ericsson and the Licensee of the Licensed Product. This contract is to be interpreted in the federal and state courts of New Jersey, in accordance with the laws of the State of New Jersey without regard to its conflict of laws principles, and the parties' consent to the jurisdiction of such courts for this purpose.

**Entire Agreement.** Licensee further agrees that this is the complete and exclusive statement of the Agreement between Licensee and Ericsson and supersedes any proposal or prior Agreement, oral or written, or any other communication between us relating to the subject matter of this Agreement.

All questions about this Agreement should be directed to:

Ericsson Inc.  
Customer Service Center (IDO)  
1 Centennial Ave.  
Piscataway, NJ 08854  
Phone: +1.844.251.0201 (USA and Canada)  
Email: [buss.document-info@ericsson.com](mailto:buss.document-info@ericsson.com)

## **END OF TERMS AND CONDITIONS**

Rev. 02/2021