

## SECTION 17120

### COMMUNICATIONS WIRES AND CABLES

#### PART 1 – GENERAL

##### 1.01 DESCRIPTION

- A. Section includes requirements for wires and cables, cable connectors, and other related materials.

##### 1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
  - 1. ICEA S-87-640 Fiber Optic Outside Plant Communications Cable
  - 2. J-STD-607-A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
- B. American Railway Engineering and Maintenance of Way Association (AREMA):
  - 1. Manual for Railway Engineering (Manual)
- C. ASTM International (ASTM):
  - 1. B3 Specification for Soft or Annealed Copper Wire
  - 2. D1248 Specification for Polyethylene Plastic Extrusion Material for Wire and Cable
  - 3. D4101 Specification for Propylene Injection and Extrusion Materials
  - 4. E814 Test Method for Fire Test of Through - Penetration Fire Stop
- D. Building Industries Consulting Services International (BICSI):
  - 1. Telecommunications Distribution Methods Manual (TDMM)
- E. Code of Federal Regulations (CFR):
  - 1. 7 CFR 1755.890 RUS Specification for Filled Telephone Cable with Expanded Insulation
  - 2. 7CFR 1755.900 RUS Specification for Filled Fiber Optic Cables
  - 3. 7CFR 1755, Bulletin 1753F-201 RUS Specification for Acceptance Tests and Measurements of Telecommunications Plant
- F. Code of Federal Regulations, Railroad Administration (FRA)

- G. California Build Code (CBC)
- H. California Electric Code (CEC)
- I. Electronics Industries Alliance (EIA):
  - 1. 310 Cabinets, Racks, Panels, and Associated Equipment
- J. Institute of Electrical and Electronic Engineers (IEEE):
  - 1. National Electrical Safety Code (NEC)
- K. Insulated Cable Engineers Association, Inc. (ICEA):
  - 1. S-84-608 Filled Telecommunications Cable, Polyolefin, Insulated, Copper Conductor
- L. National Electrical Contractors Association (NECA):
  - 1. 1 Standard Practices for Good Workmanship in Electrical Construction
- M. National Electrical Manufacturers Association (NEMA):
  - 1. WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
  - 2. WC 70 Nonshielded Power Cables Rated 2000 Volts or less for the Distribution of Electrical Energy
  - 3. WD 1 General Requirements for Wiring Devices
- N. National Fire Protection Agency (NFPA):
  - 1. 70 National Electrical Code (NEC)
  - 2. 70E Electrical Safety in the Workplace
  - 3. 72 National Fire Alarm Code
  - 4. 75 Protection of Electronic Computer Data Processing Equipment
  - 5. 101 Life Safety Code
  - 6. 130 Fixed Guideway Transit Systems and Passenger Rail Systems
  - 7. 262 Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
  - 8. 780 Installation of Lightning Protection Systems
- O. Telecommunications Industry Association/ Electronics Industries Alliance (TIA/EIA):

1. 455 Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices and Other Fiber Optic Components
  2. 492CAAB Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak
  3. 568 Commercial Building Telecommunications Cabling Standard
  4. 569 Commercial Building Standard for Telecommunications Pathways and Spaces
  5. 606 Administration Standard for the Telecommunications Infrastructure
- P. Telecommunications Industry Association (TIA):
1. 598 Optical Fiber Cable Color Coding
- Q. Underwriters Laboratories (UL):
1. 444 Communication Cables
  2. 497 Standard for Safety Protectors for Paired Conductor Communications Circuits
  3. 969 Standard for Marking and Labeling Systems
  4. 1581 Reference Standard for Electrical Wire, Cable, and Flexible Cords
  5. 1690 Data-Processing Cable

### 1.03 SYSTEM DESCRIPTION

- A. Material and workmanship of the cables shall be consistent with the following requirements:
1. The life expectancy of the cable shall be minimum 40 years in a railroad environment.
  2. The cable shall be constructed for continuous operation at 90 degrees Celsius, in a wet or dry environment.
  3. Conductor to conductor and conductor to ground resistance shall not be less than one mega-ohm.
  4. Cable shall be constructed for continuous operation at minus 40 degrees Celsius without cracking or becoming brittle.
- B. Design, installation, and testing shall comply with all applicable standards and codes listed under Reference Standards in this Section. The installation of power wire and cable shall conform to all applicable NEC standards. Installation of data

and communication cable shall conform to all applicable RUS and TIA/EIA standards.

#### **1.04 SUBMITTALS**

- A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements. Submit additional submittals upon Engineer's request.
- B. Submit product data wires and cables including complete technical information for each type cable.
- C. Submit Conduit fill calculations not to exceed the NEC specified fill ratios.
- D. Submit wire size calculations for all copper cables to determine voltage drops, and proper capacity for voltage, current and distance for all feeder, branch and device power; Ethernet (and, if applicable, serial) data and audio applications.
- E. Submit a written cable installation procedure and check-off list for approval prior to cable installation. Prepare procedure based on Contractor's review of the conduit plans, and field site survey and shall include a cabling plan and installation information for each cable pull. The installation plan shall include proper procedures for feeding cable into conduit to maintain proper bend radii, and to minimize friction. The documentation shall include details of cable lightning/surge protection and grounding.
- F. Identification Submittals: Submit wire designations scheme for the Engineer's approval. Submit sizes of letters and nature of wording for labels, number plates, and warning notices.
- G. Submit cable test plan at least 30 days in advance of testing: tests to be made, format and layout of test forms and reports, and the limiting values to be used.
- H. Submit manufacturers' qualifications.
- I. Submit certified test reports.
- J. As-Built Documentation: Refer to Section 17000, General Communications Technical Requirements, for requirements. Show all terminations, wire and cable labels/numbers, with interconnected equipment.

#### **1.05 QUALITY ASSURANCE**

- A. Quality Assurance shall be in accordance with all applicable codes and specifications.
- B. Manufacturer Qualifications: Obtain Engineer's approval of all wire and cable manufacturers. Provide data required for evaluation, and make arrangements for any demonstrations and tests required by the Engineer.
- C. Qualifications shall be based on the following criteria:

1. Past Performance and Experience: The cable manufacturer(s) shall demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations shall be provided for each cable manufacturer to be considered.
2. Quality Assurance Program: The cable manufacturer(s), in accordance with the requirements of these Specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. The Engineer's inspection of manufacturing facilities may include first article inspections, source inspections, and on-site surveys.
3. Technical Data: Provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type proposed to be supplied.

#### **1.06 PRODUCT DELIVERY, HANDLING AND STORAGE**

- A. Packing: All cable barrels/spools/drums shall not be less than twenty (20) times the finished cable nominal diameter, but not less than the minimum bending radius. Seal all ends of the cable to prevent entrance of moisture.
- B. The following particulars shall be stenciled or painted in a permanent manner on the outside of the flange of each drum.
  1. Metallic cable shall have the words "Telecommunication Cable"
  2. The manufacturer's identification of the cable type and date of manufacture
  3. Gross weight of Reel and Cable
  4. Full description of the cable
  5. Cable identification number, which is referenced to the test sheet
  6. Length of Cable
  7. An arrow showing the direction in which the drum should be rolled to gain access to the cable.
- C. Handling: Cable drums shall be complete with close fitting wooden battens to prevent damage to the cable during transit and storage.
- D. Acceptance at Site: Examine drums at installation storage area for external damage. Damaged cables will not be accepted. Inspect cables at time of delivery to the construction site to assure that no damage was done in shipping and that the specified cable was received. Inspect every reel for physical damage such as nails driven into reels to secure shipping blocks, lagging, or reel covering missing and cable and seals missing or damaged. Replace promptly all damaged or rejected cable. Conduct fiber loss (OTDR) testing on the fiber cable and continuity and cross-talk testing for the copper cabling to ensure all delivered cabling is within the vendor specified performance range upon arriving

to the site. All defective and/or underperforming cables shall be returned and substituted with the product meeting specifications. Provide to the Engineer the results of the delivery acceptance tests.

- E. Storage and Protection: Store drums with flanges upright. Store cable on drums with batten in place indoors. Store wires and cables at the construction site on solid surfaces, which shall adequately support the cable reels, but which shall be well drained and not allow accumulation of liquids, oils, or chemicals.
- F. Align and protect cable reels so as not to allow the reel flanges to damage other reels. Provide adequate aisles and barricades to allow for accessibility but prevent construction equipment from damaging the cable reels.

## **PART 2 – PRODUCTS**

### **2.01 DATA CABLE**

- A. Local distribution of data circuits for all system shall be by CAT 6 cable.
- B. Single-mode fiber shall be used to connect the main cabinet and all distribution (and any other) cabinets throughout the station.
- C. Single mode fiber shall be used for all communications purposes outside of the station facility.
- D. All installed copper and fiber cable throughout the station shall be outdoor type. Unless rated as outdoor/indoor cable type, all outdoor cabling past 50 feet from the point of entrance into the facility shall be switched to the indoor type. All outdoor cabling containing metallic (conductive) elements shall be properly lightning/surge protected at the point of entrance into the facility or cabinets according to NEC and also requirements found within these Specifications.
- E. Wire conductors shall be composed of soft or annealed copper, meeting insulating, and sensitivity and elongation requirements of ASTM B3. Joints made in conductors during manufacturing may be welded or brazed using silver alloy solder and non-acid flux.
- F. The insulation shall be colored virgin propylene copolymer meeting the requirements of ASTM D4101, or equivalent, for propylene plastic. High molecular weight polyethylene is also acceptable.
- G. All outside communication cables (those run in conduits or duct banks) shall be foam/skin insulated conductors that meet RUS Specification 7 CFR 1755.890 and shall be rodent protected.
- H. Inside wire (wiring run within any building) from telephone terminals to telephone instruments shall be 22 AWG or 24 AWG and have a characteristic impedance of 105 ohms plus or minus 15 percent. Cable shall be low smoke, non-toxic, Teflon.
- I. Communications cables shall be type and size (number of pairs) identified for the installation of the various communications systems.

- J. Communications cables shall be UL Listed and Approved for intended use. All cable shall be of Type specified by the NEC for use in plenum, non-plenum, and riser spaces.
- K. Communications cable suitable for use in ducts, plenum, and other space used for environmental air shall be UL Listed as being smoke resistant, shall be Teflon-coated and shall be classified as type CMP communications cable.
- L. Communications cable suitable for use in vertical shafts shall be UL Listed for use in such space and shall be classified as type CMR communications cable.

**2.02 UTP CAT 6 CABLE**

- A. Category 6 cable shall meet the following requirements:
  - 1. Polyethylene sheath
  - 2. Low smoke, rated for 90°C
- B. All UTP CAT 6 connections shall comply with standards per TIA/EIA-568

**2.03 UTP CAT 6 CABLE (AERIAL)**

- A. Aerial outside plant CAT 6 shall meet the following requirements:
  - 1. Polyethylene sheath
  - 2. Low smoke, rated for 90°C
  - 3. Suitable for aerial application

**2.04 COAXIAL CABLE**

- A. Where required, provide coaxial cables for video transmission; 75  $\Omega$  characteristic impedance; double braided copper shield and a 20 AWG solid copper center conductor, manufactured for the intended purpose.
- B. Types: RG6 and RG11. Do not use other types.
- C. Where required, coaxial cable used for the CCTV system shall meet the following characteristics:
  - 1. Jacket: NEC CL2P Plenum Rated
  - 2. Wires: Uniquely Color Coded
  - 3. Shield: 1 overall foil shield, with a braided shield minimum
  - 4. Capacitance:  $\cong$  53.2 pF/M
  - 5. Resistance:  $\leq$  10 ohms/100 M
- C. At no time subject any coaxial cable to a bend of less than 6-inch radius.

**2.05 RS-485/RS-422/RS-232D DATA CABLE**

- A. RS-485/RS-422/232D Data Communication Cable. If required, serial data cables used for RS-422, RS-485, or RS-232D balanced electrical transmission of data shall meet the following characteristics:
  - 1. Jacket: NEC CL2P Plenum Rated, Low Smoke
  - 2. Wires: Uniquely Color Coded
  - 3. Cable Type: Twisted pair
  - 4. Conductor gauge: 24 AWG (7 X 32 AWG) stranded, minimum
  - 5. Shield: Individually foil shielded pairs each with a drain wire; and one overall foil shield, with a braided shield minimum
  - 6. Capacitance:  $\leq 13$  pf/ft (12 pf/ft for RS-232D)
  - 7. Resistance:  $\leq 16$  ohms/1000 ft (30 ohms/1000 ft for RS-232D)

**2.06 FIBER OPTIC CABLE (ALL DIELECTRIC)**

- A. New outside plant (OSP) all dielectric single-mode fiber optic cable (FOC) shall be furnished and installed between the Communications Equipment Room (CER) and field Distribution Cabinets (DC) without intermediate distribution or cross-connects. Multi-mode cable can only be used as an exception and only if approved by the Engineer. Such cable shall be outside plant and all dielectric.
- B. Dielectric single mode (and, if used, multi-mode) fiber optic cable shall be furnished. All fiber optic strands shall be terminated with SC-type connectors. All fiber strands shall appear at assigned demarcation panels, including spare (dark) fibers.
- C. General: All outside plant FO cable shall be certified to meet applicable tests of TIA/EIA-455.
- D. Construction:
  - 1. Each fiber buffer tube will be color-coded so as to provide unique and permanently visible identification. Color coding shall be in accordance with TIA/EIA-598.
  - 2. A dielectric strength member shall be central to the cable core.
  - 3. The cable shall be designed for outdoor use and be waterproof, including water-proof tape and/or gel-filled.
  - 4. The shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of 5 ft or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.



5. Design and construction shall recognize the nature of fiber optic cables regarding installation, especially at manholes. Allowance for such fiber characteristics shall be made in cable pull budgets.
- E. Single-Mode Optical Fiber Characteristics:
1. Fiber Type: Class IVa Dispersion; Unshifted Single-mode fiber, compliant with TIA/EIA-492CAAB
  2. Core Diameter: 8.3 microns (nominal)
  3. Mode Field Diameter: 8.7 - 9.5 microns
  4. Cable Cut-off Wavelength: < 1250 nm
  5. Maximum Attenuation: 0.4 dB/km @ 1310 nm, 0.3 dB/km @ 1550 nm
  6. Zero Dispersion Wavelength: 1300 - 1322 nm
  7. Zero Dispersion Slope: < 0.095 ps/(nm<sup>2</sup>-km)
  8. Gigabit Ethernet distance guarantee: 1,310/1,550 nm-5,000 meters
- F. Cable Mechanical Specifications:
1. Nominal Jacket Wall Thickness: 0.055 in
  2. Maximum Tensile Load Rating - Installation: 600 lbs
  3. Maximum Tensile Load Rating - Maintained: 100 lbs
- G. Maximum attenuation variation during operation (minus 40 degrees C to plus 65 degrees C), installation (minus 30 degrees C to plus 60 degrees C), and storage (minus 50 degrees C to plus 70 degrees C):
1. Multimode fibers: plus 0.50 dB/km at 1300 nm
  2. Single-mode fibers: plus 0.20 dB/km at 1550 nm
- H. Cable Markings:
1. Imprinted with white characters on the outer cable jacket
  2. Permanent, insoluble in water and legible for the cable life
  3. Imprint the following identification markings on the cable jacket at intervals of not more than one meter:
    - a. Manufacturer
    - b. Year of manufacture
    - c. "OPTICAL CABLE"
    - d. Manufacturer's part number

- I. Fiber Connectors:
  - 1. Connectors shall be SC type
  - 2. Optical parameters of the connectors shall meet the requirements of TIA/EIA- 568

**2.07 AERIAL FIBER OPTIC CABLE**

- A. New outside plant (OSP) single mode gel-filled loose tube optical fiber cable shall be installed if the fiber is not in conduit.
- B. Fiber optic cable shall be manufactured for aerial applications with a messenger wire.
- C. The fiber optic cable shall comply with IEEE 802.3z.
- D. General: All outside plant aerial FO cable shall be certified to meet applicable tests of TIA/EIA-455.
- E. Construction:
  - 1. Each fiber buffer tube is color-coded to provide unique and permanently visible identification. Color-coding shall be in accordance with TIA-598.
  - 2. A dielectric strength member shall be central to the cable core.
  - 3. The cable shall be designed for outdoor use and be waterproof, including waterproof tape and/or gel-filled.
  - 4. Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of 5 ft or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.
  - 5. Central strength member shall be PE Covered Glass Reinforced Plastic.
  - 6. Messenger Wire: Flooded Stranded EHS Steel
- F. Fiber Connectors:
  - 1. Connectors shall be SC type
  - 2. Optical parameters of the connectors shall meet the requirements of TIA/EIA- 568

**2.08 SINGLE-MODE FIBER OPTIC PATCH CORDS (FAN OUT ASSEMBLY)**

- A. General:
  - 1. Described as a pre-connectorized (one end only) single mode fiber optic pigtails, suitable for splicing distribution SM fiber strands to termination equipment.

2. Glass optical core fiber with a core cladding of low density glass concentric about the optical core, a protective acrylate buffer coating, and a PVC loose tube buffer to protect the outer surface of the fiber.
  3. Tensile strength member: Aramid fiber applied over the buffered fiber followed by a PVC outer jacket.
  4. Factory-terminated on one end with an SC-type fiber optic connector.
  5. Field determined length for each patch cord, minimum 6 ft.
- B. Optical Fiber Specifications
1. Buffer Diameter: 900 microns
  2. Maximum Connector Insertion Loss: 0.5 dB
  3. Connector Return Loss: < minus 55 dB
- C. Patch Cord Mechanical Specifications
1. Nominal Cable Diameter: 0.12 in
  2. Maximum Tensile Load Rating - Installation: > 100 lbs
  3. Maximum Tensile Load Rating - Maintained: > 50 lbs
  4. Minimum Bending Radius - Installation: < 2.0 in
  5. Minimum Bending Radius - Maintained: < 1.5 in
  6. Crush Resistance: > 400 lbs/in
  7. Impact Resistance: > 1,000 cycles
  8. Flex Resistance: > 7,500 cycles
  9. Cable Length: 6.0 ft (minimum), or as determined by Contractor and approved by Engineer
  10. Patch Cord Termination
  11. One end of the fiber optic patch cord shall be factory-terminated with a SC-style connector with a strain relief boot with no terminations on the other end.
  12. Ferrule Material: Zirconia Ceramic

## **2.09 PUBLIC ADDRESS SYSTEM CABLES**

- A. Audio Cable shall be utilized to connect the Public Address output amplifier with all platform and station speakers to meet the following characteristics:

1. Speaker Cable shall be two pair.
  2. Shielded outdoor rated copper cable with outer shield drain wire.
  3. Shields shall be terminated only at the cabinet.
  4. Minimum of 16 AWG shall be used between speakers and cabinet termination. Minimum of 12 AWG shall be used between output amplifier and cabinet termination. If required by the PA load and voltage drop calculations, the Contractor may be required to utilize PA cabling of a bigger diameter than specified within this paragraph above.
  5. Conducting wires shall contain minimum of 7X26 strands.
  6. The design of the outer jacket shall correspond to indoor or outdoor types of applications.
- B. Microphone cable shall be two pair 18 AWG stranded twisted pair with shield.
- C. Local distribution cables for the PA system shall be placed in separate conduit or raceways from low-level voice and data circuits. Cable jacket shall have 600-volt rating.

#### **2.10 T1 AND CATEGORY 6 DATA COMMUNICATIONS CABLE**

- A. The cable for connection of DSX-1 compatible signals shall be Western Electric ABAM or Engineer approved equal.
- B. Cable jacket shall be low smoke and rated for the environment installed.
- C. Wires will conform to PIC color code, type twisted pair, with conductor gauge solid annealed.
- D. Each cable copper pair will be individually shielded with drain wire.
- E. Characteristic impedance will be 100 ohms @ 772 khz, with mutual capacitance at 90 nf/mi.
- F. Category 6, 4-pair data cable shall be solid conductor when used in horizontal distribution per TIA/EIA 568. Cable shall be stranded pair when used as patch cords for local equipment connectivity.

#### **2.11 LABELS AND TAGGING**

- A. All labels, number plates and warning notices shall be of durable and corrosion resistant materials securely fitted by permanent means and clearly worded. For outdoor use they shall remain legible and not suffer degradation throughout the expected life of the equipment. Labels, number plates, and warning notices shall have black lettering on a white background.
- B. Marking tags for wires and cables shall be permanent and non-conducting which securely fasten to wires and cables. Wrap-on tags are not acceptable.

1. Sleeve Type Tags: Tags for identification of individual cable conductors and field-installed wires within equipment cabinets shall be the sleeve type.
2. Flat Plastic Tags: Tags for identification of multi-pair or multi-conductor cables shall be the flat plastic laminated types.
3. Tags shall be one and one-half inches long by three-quarter inch wide with one, five-sixteenth inch hole located in the center of the width. The untreated tag shall be milk white "vinylite" or Engineer approved equal.
4. The identifying nomenclature space shall allow for three rows of lettering, and the tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall not be less than one-eighth inch.
5. Tags shall be the type that after lettering, both the face and back side of the tag shall be covered with a clear plastic coating, "vinylite", or Engineer approved equal.

## **2.12 SOURCE QUALITY CONTROL**

- A. Monitor the manufacturer(s) of the wire and cable to ensure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these Specifications and the Engineer approved submittals.
- B. Each finished wire and cable shall be traceable to the test date on file for each step in its manufacturing process.
- C. Factory Testing of Fiber Cables:
  1. Test each fiber optic cable strand on-reel prior to shipment and prior to placement on-site.
  2. Record end to end loss for each fiber at 850/1300 nm for multimode and 1310/1550 nm for single mode.
  3. Optical Time Domain Reflectometer (OTDR) with hardcopy record shall be provided for each fiber.
  4. Test optical dispersion for each fiber.
  5. Submit certified copies of tests results to the Engineer.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. Furnish and install all necessary junction boxes, pull boxes, connectors, ceiling wires, supports, cable and wire to provide a complete and reliable system. All equipment shall be properly protected from the exposure to the elements according to the manufacture recommendations and to ensure ease of future

maintenance. After installation, all such equipment shall be inspected by the Engineer to verify the Contractor installations meet the standards of the state of good maintenance.

- B. Cable ends shall be resealed promptly when a length is cut from the reel. Cable reels shall be properly handled, i.e., by using a sling and spreader attached to a shaft through the reel hubs, or by cradling both flanges between lift truck forks. The reels shall not be lifted by the top reel flange or dropped from any height. Lift truck forks shall not touch cable surfaces on the reel. Reels shall not be laid flat, and shall always be rolled in the direction opposite the cable wind on the reel.
- C. Verify that the installation design is correct and adequate for the cables to be installed. Ensure that conduit size, conduit fill, conduit bend radii, manhole and pull box/junction box spacing, manhole and pull box/junction box size, raceways, ducts, and associated hardware are proper for the intended installation.
- D. Verify the required cable length for each cable run prior to installation. Referenced drawings may be used for defining locations and estimating cable lengths. However, no existing drawings shall be used to determine final lengths and cuts. Actual lengths shall be determined by making on-site inspections and measurements.
- E. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes. Cable shall not be bent to a radius less than the greater of 20 times the diameter of the cable or the manufacturers' recommended minimum bending radius, during installation or as finally installed.
- F. Install cable per the Engineer approved installation and cable plan. Provide any installation hardware necessary to route, support, terminate, or protect any cable installation.
- G. Notify the Engineer 48 Hours notice prior to installing cables.
- H. Installation shall conform to RUS TE&CM Parts 641 and 644, and TIA/EIA 568 and TIA/EIA-569 and to applicable sections of the NEC and the requirements as specified.
- I. Where cables leave conduits, the end of the conduit shall be fitted with end bells/bushings to prevent damage to the cable.
- J. Provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as movement, vibration or sharp corners on equipment.
- K. Wires and Cables in Conduit: Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or twisted in conduit fittings or boxes. Pull and install all cables to be installed in a single conduit simultaneously.
- L. In order for unshielded twisted-pair cabling infrastructure to deliver high-speed performance, it is manufactured to very tight specifications. Consequently, to

maintain the unshielded twisted-pair cabling system performance proper installation practices shall be followed. At minimum follow the requirements listed below:

1. Do not crush the cable (by over cinching with cable ties or by using a staple gun). Use of Velcro cable ties in the rooms is required.
  2. Do not kink, knot or snag the cable while pulling; this will cause damage under the jacket and may alter cable performance.
  3. Do not exceed the recommended pulling tension. A break away swivel shall be used for fiber optic cable.
  4. Per TIA/EIA 568, do not untwist the pairs of cable beyond the absolute minimum required for termination.
  5. The cable jacket on UTP shall only be stripped back the minimum required per TIA/EIA 568 to terminate to connecting hardware.
  6. Maximum cable lengths shall not be exceeded. (295 feet for UTP horizontal runs or 328 feet for UTP channel).
  7. Properly rated patch cables will be provided and tested, from patch panels to equipment and from port to port for fiber patch panels, to provide continuity from end to end. Channel testing, inclusive of patch cords, will be in accordance with TIA/EIA 568.
  8. Per the NEC, a 40 percent fill ratio for all conduit runs is recommended for conduits with more than 2 cables.
  9. All fiber optic cables shall be set in inner-duct with an appropriate flame and smoke rating equal or better to the cables being housed.
  10. SC type connectors for fiber are recommended by TIA/EIA 568 (orange for multi-mode and yellow for single mode).
- M. Use no oil, grease, or similar substances to facilitate the pulling in of conductors. Use a specifically approved wire pulling compound.
- N. Pull in no wire or cable until all construction which might damage insulation or fill conduit with foreign material is completed.
- O. Pull wire into conduits with care and prevent damage to insulation. Use basket-pulling grips to avoid slipping of insulation on conductors. Nylon, polypropylene or hemp rope, or other "soft" surfaced cable must be used for pulling in conduit other than steel.
- P. Do not use blocks, tackle, or other mechanical means to pull wires No. 8 AWG, or smaller.
- Q. For wire/cable runs above suspended ceilings, which are not in conduit, clamp cable to underside of deck or use wire hangers; do not allow it to lie on top of

the ceiling panels. In open ceiling areas, clamp cable to underside of deck in pan troughs or along beams to aid concealment.

- R. Support wire and cable in all equipment, all terminal cabinets and in all terminals and pull boxes in vertical risers and horizontal runs. Use wire duct and strap-type supports. Furnish and install appropriate wire duct at all locations where wire duct is required for good wire management, whether shown on elevations or not. Where terminal boards are used, furnish and install wire duct on both sides. At no time shall wires cross over terminal boards. Arrange cables neatly to allow inspection, removal, and replacement.
- S. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on wire and cable.
- T. Comb wire groups. Route and support wiring and cable to achieve the highest quality appearance in all areas, including the interior of all panels and racks.
- U. Make no splices in cables. Cables shall be continuous between all designed termination points.

### 3.02 TERMINATIONS

- A. Copper Cable:
  - 1. Cables shall be trained into final position while observing minimum bending radii. Provide slack at all terminals in an amount sufficient for three re-terminations.
  - 2. Wire and cables where connected directly to equipment shall be of sufficient length to allow access for removal and inspection of equipment without having to disconnect. Wires and cables shall be continuous, without splices, between terminals within a housing and enclosure or piece of equipment.
  - 3. Termination work shall be conducted under clean and dry conditions. Connectors shall be fitted with retentive dust caps.
  - 4. For stranded copper wire, compression-type, insulated terminals in accordance with the wire and cable manufacturers' recommendations shall be used. The terminals shall be installed only with tools and techniques recommended by the terminal manufacturer. Solid wire shall be terminated by wire eyes. IDC-type termination blocks will be used only with solid conductors.
  - 5. Wires and cables shall be terminated at protected terminal blocks. Compression-type insulated terminal connections to terminal blocks shall use a single washer on top of the terminal. Wire eyes require two washers for one eye, three washers for two eyes. Connections shall be completed with double nuts torque to the rated value of the nut.
  - 6. All audio cables entering cabinets or facilities shall be protected with protection equipment specifically design for such application.



7. Protected Terminal Blocks shall be DIN rail mounted and grounded to the corresponding facility or cabinet communications ground bus.
- B. Fiber:
1. Slack in Fiber Distribution Panel (FDP) shall be restrained and shall be sufficient for strain relief per TIA/EIA 568.
  2. Attach the central strength member of cable to the FDP. Attach the outer jacket of the cable to the FDP with a cable clamp.
  3. Run fiber optic cable inside buildings in protective inner-duct. Inner-duct shall extend into the FDP for continuous cable protection and identification.
  4. Fiber optic splices shall be fusion splices. Fusion splicing shall be performed by qualified personnel utilizing splicing equipment with Local Injection and Detection (LID) to optimize splices. The loss across each spliced fiber shall be less than or equal to 0.04 dB.

### **3.03 CABLE TIES**

- A. Sized appropriately and rated to the installation conditions. Plenum rated cable ties will be used where any cable supported is rated CMP.
- B. Install at 4-foot maximum intervals, roughly centered between hangers, and at other appropriate locations to keep the wire groups neat. Ensure the cable ties do not cause cables to exceed with the minimum bend radius requirement.

### **3.04 IDENTIFICATION TAGS FOR CABLES, WIRES AND EQUIPMENT**

- A. Tag all wires and cables during the termination process, as specified herein. Tagging formats and administrative records shall be maintained for all cables in accordance with TIA/EIA-606. Labels shall be concise and preferably diagrammatic in form.
- B. Identify all conductor wires and cables whenever they enter or leave a junction box, manhole, housing, or enclosure, and at all terminals.
- C. Securely fasten marking tags to the wires and cables for identification. Place tags prior to termination.
- D. Wire designations shall consistently conform to an overall scheme approved by the Engineer to indicate location, circuit, device, wire number, terminal branch, and position, etc. Use letters and numbers.
- E. Cables and Wires:
  1. A unique identifier shall be assigned to, and marked on each cable to serve as a link to the cable record. Both ends of each cable and each cable wire and all single wires that terminate in equipment cabinets, equipment terminal blocks, punch down blocks and computers shall be permanently identified with a tag. Tags shall not obscure connection

links used between terminal binding posts. Tags shall be installed so that they may be read with a minimum of disturbance of the tags. Tags will be placed not greater than 2 inches from the point of wire or cable termination.

2. Tag Installation: Install tags and apply conductor nomenclature in accordance with the manufacturer's instructions. Installation shall result in a permanently bonded and legible identification.
  3. Spare wires for future use shall be labeled, with exposed ends taped.
- F. Post cable schedule and identification key on each equipment rack and cabinet door for future reference.

### **3.05 FIELD QUALITY CONTROL**

- A. Refer to Section 01545, Work Site Safety and Security, and General Conditions and Special Conditions in regard to safety in proximity to the operating system.
- B. Follow approved cable testing plan.
- C. Provide all instruments, materials and labor required for tests specified.
- D. Notify the Engineer of testing schedule for the purpose of witnessing complete testing on all cable installations.
- E. Follow test equipment manufacturer's instructions as to operation and electrical connections.
- F. Testing Copper Cables:
  1. The test plan shall include the insulation resistance and continuity tests. The test plan will conform to RUS Specification 7 CFR 1755 Bulletin 1753F-201 (PC-4) for multi-pair cable. Category 6 level data cables shall be tested and certified per TIA/EIA 568.
  2. All associated communications equipment not under test shall be disconnected and grounded. All electronic devices or signal equipment shall be disconnected or unplugged prior to any testing. All cable splices shall have been completed.
  3. After installation of the entire length of a cable, perform the tests listed below on each cable. To preclude damage to equipment and devices, conduct the tests before the cable is terminated at the electrical equipment. If termination has been made, disconnect cables from the equipment for testing and reconnect after completion of tests.
  4. Dielectric Test: Perform test to ensure that the cable insulation has not been impaired during installation.
  5. Continuity Test: Perform test to prove the continuity of the conductor. The test shall be made of all conductors and shields.

6. Insulation Resistance Test: Perform test to determine the conductor to ground resistance and conductor to conductor resistance. Conduct tests with a 500V motor-driven megger. Apply test voltage between the conductor and ground and hold until the reading reaches a constant value for five minutes. Insulation resistance values obtained by the megger tests shall not be less than two mega-ohms. Bring to the Engineer's attention the results of similar tests having unequal readings with the variations of 25 percent or more.
  7. Perform end-to-end tests on all cables where cables enter or leave cases, communication houses or other facilities.
  8. For each test, record all data on approved test forms.
  9. Replace with new cable any installed cable found defective during testing.
- G. Testing Fiber Cables: Refer to Source Quality Control herein for factory testing. Perform the following installed tests after installation is complete.
1. Notify the Engineer 24 hours in advance of testing.
  2. Record optical link attenuation from FDP to FDP. Record optical channel attenuation from FDP to each Distribution inclusive of optical patch cords and connections passing through multiple links (Distribution and patch panels) per TIA/EIA 568-B.3.
  3. Submit OTDR records including hardcopy and CD softcopy, for both directions of transmission, to the Engineer.
  4. Test all fibers:
    - a. OTDR tests shall be performed such that the FDP and patch panel terminations and jumpers shall be shown.
    - b. The loss across each connector and splice shall be shown. There shall be no single point loss on a fiber greater than 0.1 dB per TIA/EIA 568.
- H. For fiber optic cable, complete on-site baseline OTDR testing and submit test reports prior to cutover.
- I. For UTP CAT 6 cable, complete manufacturer recommended testing and submit test reports prior to cutover.

**END OF SECTION**