SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The Work of this Section shall consist of the labor, materials, and equipment required for furnishing and installing cable and equipment for complete and operating telecommunications system extended from the existing telecommunications infrastructure.

1.2 DESCRIPTION OF WORK

A. The work generally consists of furnishing and installing inside Technology and equipment as indicated on the drawings.

B. All items shall be furnished and installed to provide complete and operating systems extended from the existing infrastructure.

C. Contractor shall furnish and install the following:

1. Unless noted, conduits, raceways, cable tray, sleeves, pull boxes, and outlet boxes.
2. Grounding busbars, ground wires and ground clamps
3. A #14 fish wire or Jet Line No. 232 pull rope in each spare run of conduit.
4. Outlet boxes.
5. Conduits from outlet boxes to above accessible ceilings (or to accessible location if ceilings are not accessible). Refer to Electrical Drawings for locations of conduit stub-outs
6. Copper cables, including patch cords
7. Fiber optic cables, including patch cords
8. Jacks, wallplates and connectors, both copper and fiber.
9. Fiber optic termination panels
10. Fiber optic cable management ring.
11. Racks including patch panels and wire management panels.
12. “J” hooks for supporting cables.
13. Testing of all cable, copper and fiber optic
14. Splice closures
15. Innerduct
16. Fire stops in sleeves

1.3 SUBMISSIONS

A. In addition to the requirements of section 16101, the Contractor shall provide product data and shop drawings for all materials proposed for

installation under this Contract. The product data and shop drawings shall be submitted to the Owner for approval before such equipment is delivered to the site. The Contractor shall submit samples as may be required by the Owner of any article or materials to be used under this Contract, which samples, if approved, may be used on the work after serving their purpose as samples.

B. Identify submittals with the following information permanently adhered to or noted on each separate component of each submittal and also noted on the transmittal form. Mark each copy of each submittal identically, with the following:
   1. Project title and location.
   2. The Section number of the Section by which the proposed equipment is specified.
   3. The Drawing number or numbers of the Drawing or Drawings by which the proposed equipment is indicated.
   4. The name, address and telephone number of the supplier and the associated manufacturer.
   5. Submittals presented on sheets 8-1/2 inch (21.6 cm) x 11 inch (27.9 cm) or less shall be presented as part of a bound volume.
   6. Refer to the article titled "SUBSTITUTIONS" for all products which are not specified by manufacturer and catalog number and are intended to be submitted.
   7. Where products are listed by manufacturer and model number, the listing shall represent a standard of performance. These listings shall not be construed as proprietary specifications. Equivalent products may be submitted for approval and use as described in the article titled “SUBSTITUTIONS”.
   8. Contractor shall submit as-built information outlet schedules in a format determined by the Owner indicating individual jacks after the building is occupied.

1.4 SUBSTITUTIONS

A. The submissions are the Contractor's documents and the Architect's approval constitutes an acknowledgment that the documents have been submitted and nothing more. It is the Contractor's responsibility to check his own submissions for compliance with the Contract Documents and job conditions.

B. Throughout the specifications, types of materials may be specified by manufacturer's name and catalog number in order to establish standards

of quality and performance and not for the purpose of limiting competition. Unless specifically stated otherwise, the bidder may assume the phrase "or approved equal," except that the burden is upon the bidder to prove such equality. If the bidder elects to prove such equality, he must request the Architect's approval in writing to substitute such item for the specified item, and shall submit supporting data, and samples if required, to permit a fair evaluation of the proposed substitution with respect to quality, serviceability and warranty.

C. When this Contractor desires to furnish equipment of a manufacturer other than that specified or intended, he shall include a complete specification of the substituted item, along with each submission copy of shop drawings, indicating the necessary modifications to the substituted product to satisfy the requirements of the contract specifications. Manufacturer's specifications shall be written as close as possible to the contract specifications and each paragraph shall bear the same paragraph number as the contract specifications so that close comparison can be made.

D. The verification specification shall include the exact wording of the contract specification and the revised wording identified properly indicating all the deviations proposed. Each paragraph shall be denoted as "TOTALLY COMPLIES", "PARTIALLY COMPLIES", or "DOES NOT COMPLY". If no deviations are noted, the Contractor must furnish the material or equipment in accordance with the contract specifications.

E. Also, when the Contractor submits equipment or materials of the manufacturers specified, verification specifications must be submitted at the request of the Architect.

F. The Contractor is responsible for confirming that all specified products will be available in a timely manner to meet the contract schedule. Should the delivery time schedule of any specified product be an issue that could adversely affect the project schedule, the Contractor shall notify the Owner, in writing, within 14 days following the award of the Contract. Documentation as to when specified products were ordered and anticipated delivery dates will be required to be submitted to the Owner at this time. Failing to comply with this paragraph will prohibit the Contractor from substituting a specified product based on delivery time issues.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The Contractor shall submit all products per drawings and specifications for review by the Owner prior to installation. Subject to compliance with specific design and specification requirements. Manufacturers:

B. Subject to compliance with requirements, provide products by the following:
   1. Leviton.
   2. Panduit.

2.2 WIRING PATHWAY AND EQUIPMENT MOUNTING ELEMENTS

A. Cable Trays: Comply with Division 26 Section "Cable Trays for Electrical Systems".

B. Raceways, Boxes, and Cabinets: Comply with Division 26 Section "Raceways and Boxes for Electrical Systems".

C. Cable Pulling Lubrication and Lubricant
   1. The cable jacket and/or conduit innerduct walls shall be completely lubricated when cable is pulled into conduit. The lubricant shall be applied immediately before or during the pull.
   2. The cable lubricant shall meet the following performance specifications:
      a. The lubricant shall be UL or CSA listed.
      b. The lubricant shall produce no deleterious effects on physical or electrical properties of cable jackets.
      c. The lubricant shall produce no stress cracking on LDPE cable jackets when tested per IEEE Standard 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable.
      d. Cable jacket materials LLDPE, XLPE, CPE, and PVC heat aged in lubricant shall pass tensile and elongation compatibility requirements from IEEE Standard 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable.
      e. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes.
      f. The lubricant shall not phase-out after five freeze/thaw cycles or 5-day exposure at 60 degrees C.

g. A 200-gram sample of the lubricant, when placed in a one-foot, split metal conduit and fully dried for 24 hours at 105 degrees C., shall not ignite with a pilot flame and continuously burn for more than one minute at a continued heat flux of 40 kW/m^2. Total time of test shall be one-half hour.

2.3 MANAGEMENT EQUIPMENT

A. Floor Mount Equipment Racks:

1. Floor mount equipment racks shall be constructed of extruded 6061-T6 aluminum.
2. Floor mount racks shall be supplied and installed with two floor mount base angles and two top angles.
3. Floor mount racks shall have both front and rear rails tapped with #12-24 mounting holes.
4. Floor mount rails shall be tapped (#12-24) at 5/8 inch x 5/8 inch x 1/2 inch, EIA universal hole spacing on nominal 19 inches, side to side.
5. Floor mount racks shall be 7 feet in overall height and supply 45 EIA rack mount spaces.
6. Floor mount racks shall have a maximum footprint size of 15 inch x 20.25 inch.
7. Each rack shall be supplied with 100 #12-24 mounting screws.
8. Securely anchor each rack to the floor as required.
9. Racks shall be UL listed.
10. Racks shall be provided with 3/16 inch x 3/4 inch, copper ground bar with (6) each #12-24 tapped mounting holes.
11. Racks shall have a 1,000 lb. evenly distributed weight capacity.

B. Cable Management:

1. All racks shall be equipped with adequate cable management hardware to organize and strain relief both the hardwired cables on the back of the rack and patch cords on the front of the rack.
2. Racks shall be provided with double-sided, "H" shaped vertical cable management sections to provide vertical pathways for cable routing between racks.
3. Cable managers shall be provided for all patch panels.
4. Cable managers shall be designed for EIA 19 inch rack mounting.

C. Strain Relief Brackets:

1. Strain relief brackets shall be provided for each patch panel, if not factory installed.

2. Cables shall be attached to strain relief brackets with sufficient slack to allow removal of patch panel from rack for service.

2.4 GROUNDING

A. See Division 26 Section – Grounding and Bonding for Electrical Systems.

2.5 MISCELLANEOUS HORIZONTAL CABLING COMPONENTS

A. This section includes description of and requirements for horizontal telecommunications cabling.

B. General

1. The horizontal cabling is the portion of the telecommunications cabling system that extends from the work area information outlet/connector to the horizontal cross-connect in the telecommunications room. The horizontal cabling includes the horizontal cables, the information outlet/connector in the work area, the mechanical termination, and patch cords or jumpers located in the telecommunications room.
   a. NOTE - The term "horizontal" is used since typically the cable in this part of the cabling system runs horizontally along the floor(s) or ceiling(s) of a building.
2. Topology
   a. The horizontal cabling shall be a star topology. Each work area information outlet/connector shall be connected to a horizontal cross-connect in the TR/MER. Each work area shall be served by a telecommunications room.
      1) NOTE - Cabling between telecommunication rooms for the purpose of creating "bus" and "ring" topologies is considered part of the backbone cabling.
3. Horizontal Cabling Distances
   a. The maximum horizontal distance shall be 295 feet (90 m), independent of media type. This is the cable length from the mechanical termination of the media at the horizontal cross-connect in the telecommunications room to the information outlet/connector in the work area.
   b. Length limitations for cross-connect jumpers and patch cords in the cross-connect facilities, including horizontal cross-connects, jumpers, and patch cords that connect horizontal cabling with equipment or backbone cabling, shall not exceed 20 feet (6 m) in length.

1) NOTE - For each horizontal channel, an allowance for 10 additional feet (3 m) from the information outlet/connector to the work station applies. Also, for each horizontal channel, a combined total of 33 feet (10 m) is allowed for cords in the work area, and for patch cords or jumpers, and for equipment cables or cords in the telecommunications room.

4. Recognized Cable Types

a. The following types of cables are recognized by this specification for use in the horizontal cabling system. These cables are:

1) Four-pair Category 6 unshielded twisted-pair (UTP) cables.

2) RG-6/U Coaxial cable

b. The specific performance characteristics for the recognized cables, associated connecting hardware, and cross-connect jumpers and patch cords are described elsewhere.

c. Hybrid cables, consisting of more than one of the recognized cables listed herein, under a common sheath, may be used in the horizontal cabling system provided that they meet the established requirements.

C. Information Outlets

1. General

a. An information outlet is the location of the connection point between the horizontal cable and patch cords connecting devices in the work area. Connected devices are typically items such as telephones, personal computers, and graphic or video terminals, each of which may require access to the horizontal distribution facility via the information outlet.

b. Information outlet locations shall be coordinated with the furniture layout. Wall-mounted outlets are typically installed at the same height as the power outlet.

c. Information Outlet Locations

1) Information outlets shall be located, as required, in mechanical and electrical spaces to accommodate the building automation system, fire alarm system, and security system.

2) Additional information outlets will be required in areas where phones may be required for maintenance, such as mechanical rooms and electrical rooms.

3) Consideration shall be made for the installation of pay phones in areas of public access. Where pay phones are to be provided, an information outlet shall be provided.
4) Location of information outlets at cubicles shall be coordinated with the Owner.

D. Cross Connections and Interconnections

1. General

a. Horizontal voice and data cables shall be terminated on connecting hardware that meets the requirements of this specification. These cable terminations shall not be used to administer cabling system moves, adds, and changes. All connections between horizontal and backbone cables shall be made through a horizontal cross-connect.

b. Patch panels shall employ 110 style IDC hardware on the rear of the rack and 8-position, 8-wire jacks on the front. The patch panels shall accept machine generated labels and color coded icons.

c. The Category 6 enhanced patch panels shall be augmented with sufficient cable management hardware. Provide front, rear, and both sides to properly dress, terminate stress relieve and manage the installed cables and provided patch cords. A rack shall be installed to house the termination and management hardware, and the active network equipment.

d. Products for this installation shall be furnished in new and factory packaged condition. Each product shall be inspected by the Contractor to ensure completeness and that no damage was incurred during shipping. The contractor shall return to the manufacturer, any product found to be deficient. The cost of the return and replacement product shall be borne by the Contractor. All products provided for this installation shall meet the following minimum criteria.

e. Fiber optical patch panels shall be provided at required locations. Each shall be pre-assembled, rack mounted type.

2.6 4 PAIR CATEGORY 6 UTP CABLE

A. General

1. These requirements are for cables of four unshielded twisted pairs of 24 AWG copper, thermoplastic insulated solid conductors enclosed by a thermoplastic jacket.

2. All cable will conform to the requirements defined by Article 800 of the National Electrical Code. Plenum rated cable is defined as cables installed in ducts, plenums and other spaces used for environmental air and shall conform to specifications for CMP 50 (limited combustible cable) and C(UL)FT-6 . Non-plenum cable is defined as cables installed in vertical runs and penetrating more than one floor, or cable installed in vertical runs such as a shaft and shall conform to specifications for CMR and C(UL)FT-4.
3. All conductor insulation shall be FEP.

B. Physical Characteristics:

1. Shall be plenum rated and meet applicable requirements of ANSI/ICEA S-80-576. All 4 pairs must be insulated with F.E.P. No constructions that use mixed insulation materials will be allowed.
2. The diameter of the insulated conductor materials will be allowed.
3. Shall consist of (4) 22-26 AWG twisted pairs.
4. Shall be suitable for the environment in which they are to be installed.
5. The color coding pairs shall be:

   Pair 1 W-BL; BL
   Pair 2 W-O; 0
   Pair 3 W-G; G
   Pair 4 W-BR; BR

6. The overall diameter of the cable shall be no larger than 0.240 inches.
7. The ultimate breaking strength measured in accordance with ASTM D 4565 shall be 295 lb/f minimum.
8. Cable shall withstand a bend radius of 1 inch at -4°F without jacket or insulation cracking.
9. Cable shall be third party verified to meet TIA/EIA Category 6.

C. Transmission Characteristics:

1. DC resistance of any conductor shall not exceed 9.38 Ohms per 328 ft max. at 68°F. Measured in accordance with ASTM D 4566.
2. The mutual capacitance of any pair at 1 kHz for 328 ft cable shall not exceed 4.4 nF nominal.
3. DC resistance unbalanced any two conductors of any pair shall not exceed 5% when measured or corrected to 68°F in accordance with ASTM D 4566.

4. The maximum Attenuation @ 68°F ± 5.5° of any pair shall be less than the following values: (See Table 1)
5. The SRL swept measurement for 100m or longer shall meet or exceed the following values: (See Table 1)
6. The RL @ 68°F ± 5.5° between pairs in a cable for a length of 328 ft shall meet or exceed the following values: (See Table 1)
7. The NEXT coupling loss @ 68°F ± 5.5° between pairs in a cable shall be greater than or equal to the following values: (See Table 1)
8. The PSNEXT loss @ 68°F ± 5.5° between pairs in a cable for a length of 328 ft shall be greater than or equal to the following values: (See Table 1)

9.1 The ELFEXT loss @ 68°F ± 5.5° between pairs in a cable for a length of 328 ft shall be greater than or equal to the following values: (See Table 1)

10. The PSELFEXT loss @ 68°F ± 5.5° between pairs in a cable for a length of 328 ft shall not exceed the following values: (See Table 1)
11. The propagation delay of any pair at 10 MHz shall not exceed 5.7 ns/m.

Freq MHz	Attenuation (dB)max/ 100m	SRL (dB)min	RL (dB)min	NEXT (dB)min	PS-NEXT (dB)min	ELFEXT (dB)min	PS-ELFEXT (dB)min	ACR (dB)min / 100m	PS-ACR (dB)min / 100m
1.0	2.0	25.5	20.0	78	76	75	72	76	74
4.0	3.8	25.5	23.0	69	67	63	60	65	63
10.0	6.0	25.5	25.0	63	61	55	52	57	55
16.0	7.6	25.5	25.0	60	58	51	48	52	50
20.0	8.5	25.5	25.0	58	56	49	46	50	48
31.25	10.7	24.5	23.6	55	53	45	42	44	42
62.5	15.4	23.0	21.5	51	49	39	36	36	34
100.0	19.8	22.0	20.1	48	46	35	32	28	26
200.0	29.0	20.5	18.0	44	42	29	26	15	13
250.0	32.8	20.0	18.3	42	40	27	24	10	8

350.0	39.8	19.3	16.3	40	38	--	--	--	--
400.0	43.0	19.0	15.8	39	37	--	--	--	--
500.0	48.9	18.5	15.2	38	36	--	--	--	--

Table 1

D. Quality Control
   1. Every Reel shall be tested for all characteristics listed in Table 1. This testing shall be performed using a sweep test method and include frequencies from 1 MHz to 500 Mhz.
   2. Every reel shall be provided with the nominal velocity of propagation value to be used in testing.

E. Test Report
   1. A test report shall be attached to each reel of cable indicating the Reel number, the date of the test, and test results for each pair. At a minimum, test results will be shown for the parameters listed above for SRL, Attenuation, Crosstalk (NEXT), Power Sum Next. Characteristic impedance shall be shown for each pair. Nominal velocity of propagation shall be shown.

F. Cable Jacket
   1. Non-plenum rated cables shall have a PVC jacket.
   2. Plenum rated cables shall have an FEP jacket (listed limited combustible).

2.7 INFORMATION OUTLET CONSTRUCTION

A. Outlet Plates
   1. The outlet plate shall be mounted to a single-gang flush mounted box provided by the contractor. Outlet plates shall be thermoplastic in the offices and SST in all other locations. The outlet plates shall accept machine generated labeling. Outlet plate color shall be coordinated with Architect and Owner.

B. Category 6 UTP Jacks
   1. Jacks shall be selected to compliment the enhanced performance characteristics of the cable.
   2. Jacks must be capable of supporting inline power per IEEE 802.3af Standard for Powered Ethernet.
   3. Eight-wire, eight-position modular jacks shall be used for all information outlets. Each jack shall be fed by a separate four pair

cable sheath. All four pairs shall be wired to the jack using TIA/EIA-568B wiring scheme. The jacks shall employ 110 style IDC contacts for termination of the wire.

4. Jack housings shall be polycarbonate complying to UL 94V-2 flammability rating. Contact material shall be gold plating over base metal on mating area. Jack pins shall be specifically designed to not deform or have degradation of service occur, when a 4 or 6 pin modular plug is inserted into an 8 pin modular jack.
5. All Category 6 outlets shall conform to TIA/EIA 568B or latest edition Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section, and be part of the UL LAN Certification and Follow-up Program, and shall meet or exceed the following electrical and mechanical specifications:
   a. Electrical Specifications:
      1) TIA/EIA 568B Category 6 enhanced minimum requirements.
      2) Insulation Resistance: 500 MΩ minimum.
      3) Dielectric withstand voltage 1,000 VAC RMS, 60 Hz minimum, contact-to-contact and 1,500 VAC RMS, 60 Hz minimum from any contact to exposed conductive surface.
      4) Contact Resistance: 20 mΩ maximum.
      5) Current Rating: 1.5A at 68 degrees F. per IEC Publication 512-3, Test 5b.

Frequency	Worst Pair NEXT (maximum) MPS100 Outlet Power Sum **	Attenuation (maximum) (dB) MPS100 Outlet Power Sum **
1.00 MHz	87	0.02
4.00 MHz	75 dB	0.02
8.00 MHz	69 dB	0.02
10.00 MHz	67 dB	0.02
16.00 MHz	63 dB	0.03
20.00 MHz	61 dB	0.03
25.00 MHz	58 dB	0.03
31.25 MHz	56 dB	0.04
62.50 MHz	49 dB	0.08
100.00 MHz	42.9 dB	0.07

   b. Mechanical Performance:

1) Plug Insertion Life: 750 insertions.
2) Contact Force: 3.5 oz. minimum using FCC-Approved modular plug.
3) Plug Retention Force: 20 lb. minimum between modular plug and jack.
4) Temperature Range: -40 degrees to 150 degrees F.

6. UL Verified Category 6 Electrical Performance
   a. Comply with FCC Part 68
   b. ISO 9001 Certified Manufacturer

C. UTP Plugs with Enhanced Performance Characteristics
1. Eight-wire, eight-position modular plugs shall be used for all UTP cable assemblies.
2. Plugs must be capable of supporting inline power per IEEE 802.3af standard for powered Ethernet.
3. Plug housings shall be polycarbonate complying with UL 94V-2 Flammability rating. Contact material shall be gold over base metal plating on mating area and termination end.
4. Plugs shall be rated for Category 6.

2.8 COAXIAL CABLE

A. RG-6/U: NFPA 70, Type CATV or CM.
1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Jacketed with black PVC or PE.
4. Suitable for indoor installations.

B. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
1. CATV Plenum Rated: Type CATVP, complying with NFPA 262.

2.9 COAXIAL CABLE HARDWARE

A. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.10 MISCELLANEOUS BACKBONE CABLING COMPONENTS

A. This Section includes description of and requirements for telecommunications cabling backbones.

B. General

1. The function of the backbone cabling is to provide interconnections between telecommunications rooms, communications equipment rooms, and entrance facilities in the telecommunications cabling system structure. Backbone cabling consists of the backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection. Backbone cabling also includes cabling between buildings.
2. In planning the routing and support structure for the backbone copper cabling, care shall be taken to avoid areas where sources of high levels of EMI, such as motors and transformers, may exist. ANSI/TIA/EIA-569 specifies separation of the backbone cabling pathways from typical sources of EMI.
3. The backbone cabling shall also include those cables that run from the TR's wall field to the network racks.

C. Topology

1. Star Topology
   a. The backbone cabling shall use the conventional hierarchical star topology wherein each horizontal cross-connect in a telecommunications room is cabled to a main cross-connect or an intermediate cross-connect then to a main cross-connect, except as noted. There shall be no more than two hierarchical levels of cross-connects in the backbone cabling. From the horizontal cross-connect, no more than one cross-connect shall be passed through to reach the main cross-connect. Therefore, interconnections between any two horizontal cross-connects shall pass through three or fewer cross-connects. Only a single cross-connect shall be passed through to reach the main cross-connect.
   b. Backbone cabling cross-connects may be located in telecommunications rooms, equipment rooms, or at entrance facilities. Bridged taps shall not be used as part of the backbone cabling.

2. Accommodation of Non-Star Configurations
   a. Systems that are designed for non-star configurations such as ring, bus, or tree, can be accommodated by the star topology through the use of appropriate interconnections, electronics, or adapters in the telecommunications rooms.

D. Backbone Cabling Distances
1. The distance between the entrance point and the main cross-connect shall be included in the total distance calculations. The length and type of media (including gauge size for copper), shall be recorded and be provided to the Owner.
2. In the main cross-connect, jumper and patch cord lengths shall not exceed 65 feet (20 m). In the intermediate cross-connect, jumper and patch cord lengths shall not exceed 65 feet (20 m).
3. Telecommunications equipment that connects directly to main or intermediate cross-connects should do so via cables of 98 feet (30.5 m) or less.
4. The maximum distance shall be 295 feet (90 m), for Category 6 UTP media. This is the cable length between the mechanical terminations of the media at each horizontal cross-connect. Length limitations for cross-connect jumpers and patch cords in the cross-connect facilities, including cross-connects, jumpers, and patch cords that connect horizontal cabling with equipment or backbone cabling, shall not exceed 20 feet (6 m) in length.

E. Recognized Cable Types
1. The following types of cables are recognized for use in the backbone cabling system. These cables are:
   a. Multimode: 50/125 micron optical fiber (inside plant).
   b. Four-pair Category 6 unshielded twisted-pair (UTP) cables.
2. The specific performance characteristics for the recognized cables, associated connecting hardware, and cross-connect jumpers and patch cords are described elsewhere.
3. Hybrid cables, consisting of more than one of the recognized cables listed herein, under a common sheath, may be used in the backbone cabling system provided that they meet the established requirements.

F. Cross Connections & Interconnections
1. General
   a. Horizontal and backbone building cables shall be terminated on connecting hardware that meets the requirements of this

specification. These cable terminations shall not be used to administer cabling system moves, adds, and changes. All connections between horizontal and backbone cables shall be made through a horizontal cross-connect.

b. Equipment cables that consolidate several ports on a single connector shall be terminated on dedicated connecting hardware. Equipment cables that extend a single port appearance may either be permanently terminated or interconnected directly to horizontal or backbone terminations.

c. Products for this installation shall be furnished in new and factory packaged condition. Each product shall be inspected by the Contractor to ensure completeness and that no damage was incurred during shipping. The Contractor shall return to the manufacturer, any product found to be deficient. The cost of the return and replacement product shall be borne by the Contractor. All products provided for this installation shall meet the following minimum criteria.

d. Rack and/or wall mounted termination blocks shall be provided for termination of high pair count Cat 3 cables. These termination blocks shall employ 110 Style IDC hardware.

e. Only 110 style of IDC hardware shall be permitted for all connections.

f. Contractor shall provide 110 to 8P8C modular patch cords. Provide quantities of (1), (2), (3), or (4) pair 110's as required by the Owner.

G. Backbone Distribution Cable Requirements

1. Backbone distribution cables shall be installed between the main and intermediate (horizontal) cross-connect patch panels. Backbone distribution cables shall be manufactured in compliance with the specifications.

2. All cables shall be furnished in full, factory packaged reels. The reels shall be marked with the respective cable part number and lot number by the manufacturer. The supplier shall provide manufacturer's proof of compliance with the required manufacturing guidelines presented in the aforementioned standards. Each reel shall be visually inspected upon receipt and prior to installation to ensure that no damage was incurred during shipment. Any damaged cable shall be returned to the manufacturer for replacement of the

entire reel. The cost for replacement cable shall not be passed on to the Owner.

2.11 50/125 MICRON MULTI-MODE OPTICAL FIBER

A. Optical fiber requiring the use of mode conditioning patch cords when using a laser transmitter shall not be acceptable.

B. General:

1. All fibers in the cable shall be usable and meet this specification. The entire cable shall be replaced for a single failure at no additional cost to the Owner.
2. Each optical fiber shall consist of a doped silica core surrounded by a concentric glass cladding. The fiber shall be matched clad design.
3. The fiber shall be designed to support IEEE 802.3ae performance criteria, including laser based 10 gigabit ethernet for 10GBASE-SX to 300 meters, IEEE 802.3 performance criteria, including laser based gigabit Ethernet for both 1000 BASE-SX at 1000 meters and 1000 BASE-LX at 600 meters
4. All optical fiber provided shall be of the same manufacturer and part number throughout the installation.
5. All connectors, hardware, and fiber assemblies shall be Laser Optimized 50um.

C. Optical Parameters

1. Attenuation
   a. The attenuation, of the cabled fiber, shall not exceed 3.5 dB/km at 850 nm and 1.0 dB/km at 1300 nm. The typical attenuation values should be 3.0 dB/km at 850 nm and 1.0 dB/km at 1300 nm.
   b. Attenuation measurements shall be made in accordance with either ANSI/EIA/TIA-455-46 (Spectral Attenuation Measurement for Long-Length Graded-Index Optical Fibers) or with ANSI/EIA/TIA-455-61 (Measurement of Fiber or Cable Attenuation Using an OTDR).
2. Bandwidth
   a. The minimum LED over filled launch bandwidth shall not be less than 1500 MHz-km at 850 nm and 500 Mhz-km at 1300 nm.
   b. The minimum Effective Modal Bandwidth (EMB) of 2000 MHz*km @850 nm with laser performance specified to achieve 1000 meters for gigabit ethernet (IEEE, 802.3Z) standard compliant links.
3. Numerical Aperture
   a. The numerical aperture shall be .200 ± 0.015.

4. Macrobending Attenuation
   a. The maximum induced attenuation shall be less than or equal 0.5 dB at 850 and 1300 nm when wound 100 turns on a 75 mm diameter mandrel.
5. Group Refractive Index
   a. The group refractive index shall be 1.496 at 850 nm and 1.487 at 1300 nm.

D. Geometrical Parameters
1. Cladding Diameter
   a. The cladding outside diameter shall be 125.0 ± 2.0 µm.
   b. The cladding diameter shall be measured in accordance with ANSI/TIA/EIA-455-176 (Method for Measurement of Geometry by Automated Grey-Scale Analysis).
2. Cladding Non-Circularity
   a. The cladding non-circularity shall be less than 5%.
   b. The cladding non-circularity shall be measured in accordance with ANSI/TIA/EIA-455-176 (Method for Measurement of Geometry by Automated Grey-Scale Analysis).
3. Core/Cladding Concentricity
   a. The offset between the center of the core and the center of the cladding shall be less than 3.0 µm.
4. Coating
   a. The coating shall be a U.V. curable acrylate and shall be 245 µm ± 10 microns in diameter. The coating shall be readily removable with commercially available stripping tools.
   b. Measurements shall be in accordance with either EIA-455-55A, Methods for Measuring the Coating Geometry of Optical Fibers.
5. Coating Non-Circularity and Concentricity Error
   a. The coating non-circularity shall be less than or 2%.
   b. Measurements shall be in accordance with either EIA-455-55A, Methods for Measuring the Coating Geometry of Optical Fibers.
6. Core Diameter
   a. The core diameter shall be 50um ± 3.0 µm.
   b. The core diameter shall be measured in accordance with EIA/TIA-455-58 (Core Diameter Measurement of Graded-Index Optical Fibers).

7. Core Non-Circularity
   a. The core non-circularity shall be less than or equal 5%.
   b. The core non-circularity shall be measured in accordance with ANSI/TIA/EIA-455-176 (Method for Measurement of Geometry by Automated Grey-Scale Analysis).
8. Fiber Tensile Proof Test
   a. The individual fibers shall be subjected to minimum proof stress of 0.70 GN/m2 (100 kpsi).
   b. Testing shall be in accordance with EIA-455-31A.

E. Cable Jacket
1. Non-plenum rated cables shall have a PVC jacket.
2. Plenum rated cables shall have a plenum rated PVC jacket.
3. Cable Jacket color shall be Aqua.

F. Cable shall be supplied with 2 000 mm of extra length at both ends. The inner end, shall be fastened so as to prevent the cable from becoming loose during shipping and installation.

G. Cable Jacket:
1. Non-plenum rated cables shall have a PVC jacket.
2. Plenum rated cables shall have a plenum rated PVC jacket.
3. The cable jacket shall be printed with the following information: Manufacturer, Manufacturer's part number, cable type, number of strands, UL Type, and sequential footage markings.
4. Cables not installed in conduit, or solid bottom cable tray with a solid cover, shall be plenum rated and enclosed in an unjacketed interlocking steel armor which shall be painted orange. The armor shall be marked per NEC and TIA requirements.

H. Cable shall be supplied with no more than 5 feet (1525 mm) of extra length at each end.

2.12 CROSS CONNECTION AND INTERCONNECTION PRODUCT COMPONENTS

A. UTP Patch Panels (Voice/Data)
1. UTP patch panels shall meet or exceed the rating for Category 6 in accordance with ANSI/TIA/EIA-568-B specifications.
2. Patch panels shall incorporate 110 style IDC terminations mounted to a PC board on the rear of the panel.
3. Patch panels shall have 8-position, 8-wire jacks wired in accordance with the T568B wiring scheme.
4. Patch panels shall have or be installed with rear strain relief bars or brackets to facilitate the installation of the UTP cables.

5. Patch panels shall accommodate front and rear labeling for each discrete 4-pair circuit.
6. Patch panels shall not occupy more than one EIA rack space 1.75 inch (4.4 cm) for every 24 port positions.
7. Contacts shall be plated with a minimum of 50 micro inches of gold.
8. Modular outlets shall be compliant with FCC CFR 47 part 68 and subpart F and IEC 603.7.

B. Patch Cord Assemblies (CAT 6)

1. General:
   a. The contractor shall provide and deliver to the Owner, patch cords assemblies. Work area cables shall be (3) meters in length and patch cords for the telecommunications closet shall be pre-manufactured provided in standard lengths to avoid excessive slack.
   b. Patch cords shall be complimentary to the link cable and, when installed, shall constitute a manufacturer approved channel including enhanced characteristics.
2. 4 Pair Category 6 UTP Patch Cords:
   a. Provide Category 6 Modular Patch Cords for each assigned port on the patch panel. All cords shall conform to the requirements of EIA/TIA 568B or latest edition Commercial Building Telecommunications Cabling Standard, Horizontal Cabling Section, and be part of the UL LAN Certification and Follow-up Program. Cords shall be equipped with an 8 pin modular connector on each end.
   b. All Category 6 cordage shall be round, and consist of 24 AWG copper, stranded conductors, tightly twisted into individual pairs and shall meet or exceed the electrical specifications listed below:

DC Resistance per lead	9.4Ω/328 ft. (100m), maximum
DC Resistance unbalance	5%, Maximum
Mutual Capacitance	6.6 nF/328 ft. (100m), maximum
Characteristic Impedance	100Ω +\- 15% from 1 to 100 MHz

   c. The Category 6 enhanced patch cord shall incorporate the "cross-over lead" concept. The patch cord shall have built-in exclusion

features to prevent accidental polarity reversals and split pairs.

d. UL Verified for EIA/TIA 568B Electrical Performance
UL Listed for Fire Safety
ISO 9001 Certified Manufacturer
Austel Approved
FCC Compliant

e. Confirm patch cord lengths with Owner.

C. Fiber Optic Connectors (Multimode):

1. Fiber optic connectors shall be LC-style duplex connectors.
2. All connectors provided shall be of the same manufacturer and part number throughout the installation.
3. The duplex LC type connectors shall have the following characteristics:

Insertion Loss:	Multimode - 0.3 dB typical
Reflectance:	≤ -55 dB
Durability:	≤ 0.5 dB change, 500 remating
Tensile Strength:	≤ 0.2 dB change, 20 lb.
Temperature Cycling:	≤ 0.3 dB change -40°F + 167°F, 21 cycles
Normal Fiber OD:	125 µm
Materials:	Ferrule: Preradiused Zirconia
	Housing: Composite

4. All connectors shall be heat cured epoxy/polish connectors.

D. Multimode Optical Fiber Patch Cords

1. Duplex LC to Duplex LC

a. Optical fiber patch cords shall be measured for insertion loss with the following values for each connector (each fiber in Duplex SC connectors): typical of 0.3 dB and maximum of 0.5 dB.

b. Assemblies shall be discrete 2 fiber zip cord construction suitable for use in indoor spaces and shall contain a riser-rated or plenum–rated jacket.

c. Patch cords shall contain 50/125 um graded-index, multimode fiber compliant with TIA/EIA-568-B.3 terminated with Duplex LC style connectors.

d. Cable assemblies shall be orange and shall conform to the following length(s).

Length	Quantity
6 ft.	48
10 ft.	48

e. Confirm patch cord lengths with Owner.

E. Duplex LC to Duplex LC

1. Optical fiber patch cords shall be measured for insertion loss with the following values for each connector (each fiber in Duplex SC connectors): typical of 0.3 dB and maximum of 0.5 dB.
2. Assemblies shall be discrete 2 fiber zip cord construction suitable for use in indoor spaces and shall contain a riser-rated or plenum–rated jacket.
3. Patch cords shall contain 8.3/125 micron single mode fiber compliant with TIA/EIA-568-B.3 terminated with Duplex LC style connectors.
4. Cable assemblies shall be orange and shall conform to the following length(s).

Length	Quantity
6 ft.	12
10 ft.	6

F. Fiber Termination Patch Panels

1. Fiber termination panels shall be capable of handling a minimum of 24 Duplex LC style fiber optic connectors, fiber slack, and patch cord wire manager within one EIA rack space 1-3/4 inches.
2. Fiber termination panels shall be 19 inches rack mountable.
3. Fiber termination panels shall be equipped with cable strain relief brackets.
4. Fiber termination panels shall provide ample storage and handling for up to 36 inches of cable slack per fiber.
5. Fiber termination panels shall fully enclose the installed cable and patch cord cable interface when the panel is in the closed position.
6. Housing shall contain splice trays suitable for a total of 24 fusion splices.

2.13 FIBER OPTIC INTERCONNECTION HARDWARE

A. Rack Mountable:

1. All rack-mounted hardware shall be mountable in an EIA compatible 19 inch rack. One EIA rack space is defined as being 1-3/4 inch in height with mounting holes on each side of the rack and center to center hole spacing. The center to center distance of the bottom hole in a rack space to the top hole in the next lower rack space is 1/2 inch. An optional wall mounting kit is available when wall mounting is required.
2. The connector housing shall be single cabinet construction and combine splicing and terminations in one unit.
3. The unit shall be mounted with a nominal 4.25 inch frontal projection or flush mounted.
4. There shall be full access to the front and rear of the housing.
5. The rack-mounted housings shall meet the requirements of TIA/EIA-568-B and UL V-0.
6. Housings shall be manufactured using 16 gauge aluminum or equivalent for structural integrity and shall be finished with a wrinkled black powder coat for durability. All fasteners shall be black chromated to match the housing. The housing shall have a durable, polycarbonate-tinted front door for viewing patch cords.
7. The housing shall have multiple grommeted cable entry and grommeted patch cord exit locations.
8. The housing shall support single mode and multimode applications.
9. The housing shall have provisions for a clamshell type cable clamping mechanism to provide cable strain relief.
10. The housing shall have locations available for locking the front and/or rear door.
11. Front and rear doors of the connector housings shall be hinged and removable to ease installation. Front and rear doors shall utilize a slam latch to provide quick access and closing.
12. The connector panel housings shall use a strain relief bracket which shall allow the user to install up to two clamshell type cable strain relief on the side of the housing.
13. The connector housings shall have a labeling scheme that complies with EIA/TIA-606.

B. Connector Panels: Both rack-mountable and wall-mountable connector housings shall use an interchangeable connector panel. The connector

panel is defined as a removable plate used to mount connector adapters and is mounted within a modular outer housing. The connector panel shall have the following characteristics:

1. The connector panel shall be available in only one mounting footprint for panels with six or twelve duplex connector adapters in each panel. The panel shall be attached with at least two push-pull latches to allow quick installation and removal.
2. The connector panel shall be available in a 12/24 fiber Duplex LC style with a 6/12 port configuration per panel.
3. The connector panel shall have removable colored icons.
4. Blank connector panels shall be available to fill unused housing space. Blank panels shall be finished with a wrinkled black powder coat for durability. The blank panel shall be attached with at least two push-pull latches to allow quick installation and removal.
5. Panels shall be manufactured using cold rolled steel or equivalent for structural integrity.
6. Panels shall be finished with a wrinkled black powder coating to match other hardware and to provide a durable finish.

C. Jumper Management Panels: The rack mount hardware shall incorporate In-rack and vertical jumper management techniques. One or both methods may be used as required. In-rack management panels shall be available to provide jumper routing to the connector housings and electronic hubs.

1. In-Rack jumper management panels shall be available in 1-RMS, 2-RMS and 3-RMS sizes and shall have removable front covers to conceal and protect the jumpers when installation is complete. The front of the jumper management panel cover shall be flush with the front door of the connector housing.
2. Jumper management panels shall be designed to maintain a 1.50 inch minimum bend radius when transitioning between routing panels and frame verticals or connector housings and shall be finished with a wrinkled black powder coat for durability. All fasteners shall be black chromated to match the housing.
3. The vertical jumper routing area shall have vertically adjustable cable retaining rings. The adjustable routing rings shall include a swing out door for ease in jumper routing. The sides of the rings shall have radius guides to provide minimum bend radius control. The rear side of the vertical routing area shall also provide cable

retaining rings that hold data cables close to the rack to eliminate accidental snags from maintenance personnel.

4. Slack storage spools shall be provided when jumper slack storage is required in-rack.
5. Slack storage shall be available using both In-Frame and vertical storage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements to receive cable. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Installers: Subject to compliance with requirements, installation of specified system shall be by the following:
   1. Empire Communications Services.
   2. Fibercom Inc.
   3. PennNet
B. Install raceway components as indicated, according to manufacturer's written instructions. Use techniques, practices, and methods that are consistent with EIA/TIA-569A.
C. Separation of Wires: Comply with EIA/TIA-569A rules for separation of unshielded copper voice and data system cables from potential EMI sources, including electrical power lines and equipment. Insure that all communication outlet locations in wall, surface mounted raceways, or floor boxes have adequate backbox enclosures to house communication wiring.
D. Racks
   1. Reference manufacturer's proper installation practices for the cable support hardware and define cable dressing and termination procedures.
   2. Racks shall be installed in the following manner:
      a. Floor mount racks shall be securely attached to the floor using minimum 3/8 inch (.95 cm) hardware. Racks installed on raised access flooring shall be anchored to the concrete floor slab, through the raised floor with threaded rods.

b. All racks shall be grounded in accordance with this document the NEC and the equipment manufacturers requirements.
c. Rack mount screws (#12-24) not used for installing hardware shall be bagged and left with the rack upon completion of the installation.
d. Inter-bay and end-cap managers shall be installed to the rear mounting rail of the rack using all available mounting holes.
e. Cables shall be securely fastened to the cable managers with velcro ties.
f. Cable feeds shall alternate left and right to minimize congestion at the top of the rack.

E. Horizontal Cable Installation
1. Cable shall be installed in accordance with manufacturer's recommendations and best industry practices.
2. All cables shall be installed in the following manner:
a. Cable raceways shall not be filled greater than the NEC maximum fill for the particular raceway type. Cabling shall be installed within raceway where no wire basket cable tray is accessible. Where cable tray is accessible, install cabling within tray.
b. Cables shall be installed in continuous lengths from origin to destination (no splices - field or factory).
c. The cable's minimum bend radius and maximum pulling tension shall not be exceeded.
d. Cable shall be installed above fire-sprinkler systems and shall not be attached to the system or any ancillary equipment or hardware. The cable system and support hardware shall be installed so that it does not obscure any valves, fire alarm conduit, boxes, or other control devices.
e. Any cable damaged or exceeding recommended installation parameters during installation shall be replaced by the contractor prior to final acceptance at no cost to the Owner.
f. Cables shall be identified by a self-adhesive label or sleeve in accordance with this specification. The cable label shall be applied to the cable behind the faceplate, on a section of cable that can be accessed by removing the cover plate, and at the patch panel, near the end of the cable so it can be viewed, and properly associated with the termination, without the need to

unbundle cables. Cable labels within the bundle shall not be accepted.

g. Cables shall not be allowed to lay on the ceiling slab or ceiling support structure.

3. In addition, different cable types shall be installed under the following provisions:

a. Unshielded Twisted Pair

1) Unshielded twisted pair cable shall be installed so that there are no bends less than four times the cables outside diameter (4 X cable O.D.) at any point in the run and at the termination field.

2) Pulling tension on 4-pair UTP cables shall not exceed 25 lbs. for a single cable or cable bundle.

F. Outlet Installation

1. All outlets shall be installed in the following manner:

a. Wall mounted outlets shall be attached to 4 inches (10 cm) x 4 inches (10 cm) x 2-1/2 inches (6.4 cm) deep boxes with raised extension (flush mount) and 4 inches (10 cm) x 4 inches (10 cm) x 2-3/4 inches (7 cm) (surface mount).

b. Wall mounted outlets shall be installed with the center of the plate at 18 inches (45.7 cm) above finished floor (AFF) unless otherwise indicated. The faceplates shall be installed in a vertical orientation.

c. Any unused faceplate positions shall be covered/filled with a blank insert made of the same or compatible material as the faceplate.

G. Horizontal Cross-Connect Installation

1. Termination and management hardware shall be installed in the following manner:

a. Cables shall be dressed and terminated in accordance with the recommendations made in the TIA/EIA-568-B document, manufacturer's recommendations and/or best industry practices.

b. Pair untwist at the termination shall not exceed 1/2 inch (1.27 cm).

c. Bend radius of the cable in the termination area shall not exceed 4 times the outside diameter of the cable.

d. Cables shall be neatly bundled and dressed to their respective panels. Each panel shall be fed by an individual bundle

separated and dressed back to the point of cable entrance into the rack.

e. The cable jacket shall be maintained as close as possible to the termination point.

f. Each cable shall be clearly labeled where it can be viewed and properly associated with termination, without the need to unbundle cables behind the patch panel. Cables labeled within the bundle shall not be acceptable.

g. Fiber slack shall be neatly coiled within the fiber termination panel. No slack loops shall be allowed external to the fiber panel(s). Fiber cables shall be neatly bundled and dressed to their respective panels.

h. Each cable shall be clearly labeled within the enclosure so that the label can be viewed when the panel is opened. Cables labeled within the bundle shall not be acceptable.

i. Dust caps shall be installed on the connectors and couplings at all times unless physically connected.

2. Patch Panels:

a. Panels shall be installed to provide minimal signal impairment by preserving wire pair twists as closely as possible to the point of mechanical termination. The amount of untwisting in a pair as a result of termination to the patch panel shall be no greater than .50 inch (1.27 cm).

b. Panels shall be installed according to manufacturer's instructions and properly mounted to a rack, cabinet, bracket or other appropriate mounting device.

c. Panels shall be installed such that cables terminated to the panel can maintain minimum bend radius of at least 4 times the cable diameter into the IDC contacts.

d. Panels shall be properly labeled on front and back with the cable number and port connections for each port.

H. Punch-Down Wiring Blocks

1. Installed on plywood backboard so that the top of wiring block is nominal 5-1/2 feet (1.7 m) AFF. Mount blocks with steel, zinc plated slotted hex head #10 x 20 drill screws.

2. Installed on racks utilizing back plates specifically designed for the purpose.

3. Install designation strips color-coded with industry-standard color-coded field as follows:

Description	Color
C.O. Circuits	Orange
Common Equipment - PBX, LAN's, Muxes	Purple
First Level Back Bone Cable	White
Second Level Back Bone Cable	Gray
Horizontal Wiring	Blue
Auxiliary Circuits - Alarms, Security	Yellow
Future use and Key Systems	Red
Inter-building Campus Backbone	Brown

4. Install red insulator clips on all special circuits in the telecommunications room.

I. Backbone Cable Installation

1. General
   a. Cable shall be installed in accordance with manufacturer's recommendations and best industry practices.
   b. All cables terminated on rack mounted equipment shall be strain relieved to allow patch panel to be removed and worked on from the front.
2. All cables within conduit shall be installed in the following manner:
   a. Cable raceways shall not be filled greater than the NEC maximum fill for the particular raceway type. Cabling shall be installed within raceway where no wire basket cable tray is accessible. Where cable tray is accessible, install cabling within tray.
   b. Cables shall be installed in continuous lengths from origin to destination (no splices - field or factory).
   c. The cable's minimum bend radius and maximum pulling tension shall not be exceeded.
   d. Cable shall not be attached to the fire system or any ancillary equipment or hardware. The cable system and support hardware shall be installed so that it does not obscure any valves, fire alarm conduit, boxes, or other control devices.

e. Any cable damaged or exceeding recommended installation parameters during installation shall be replaced by the contractor prior to final acceptance at no cost to the Owner.

f. Cables shall be identified by a self-adhesive label or sleeve in accordance with this specification. The cable label shall be applied to the cable on a section of cable near the end that can be viewed, and properly associated with the termination, without the need to unbundle cables. Cable labels within the bundle shall not be accepted.

3. All cables within cable tray and on cable runway shall be installed in the following manner:

a. Cables installed in cable tray and on cable runway shall be organized into bundles no larger than 2.50 inches (6.4 cm) in diameter. Hook and loop ties shall be spaced no farther than 5 feet (152 cm) on center in a horizontal line and no farther than 12 inches (30.5 cm) on center in a vertical line. Crosses and drops shall be neat and organized.

4. In addition, different cable types shall be installed under the following provisions:

a. Unshielded Twisted Pair

1) Unshielded twisted pair cable shall be installed so that there are no bends less than four times the cables outside diameter (4 X cable O.D) at any point in the run and at the termination field.

2) Pulling tension on 4-pair UTP cables shall not exceed 25 lb/f for a single cable or cable bundle.

3) Cables shall be dressed and terminated in accordance with the recommendations made in the TIA/EIA-568-B document or most current documentation, manufacturer's recommendations and/or best industry practices.

4) Pair untwist at the termination shall not exceed .50 inch (1.27 cm).

5) The cable jacket shall be maintained as close as possible to the termination point.

6) All modular jacks shall be oriented with the locking tab slot towards the floor.

7) All terminations shall be made using industry standard tools that insert and trim the wires.

8) All terminations shall be made according to the T568B wiring scheme.

b. Inside Plant - Copper:

1) All placement shall conform to industry standards with regard to anchoring, cable support and separation from other facilities.
2) Cables and innerduct shall not sag or droop but shall be installed so as to maintain a flat plane with smooth transitions from one level or direction to another.
3) All cables shall be sufficiently racked and supported in order to eliminate stress on the cable.

c. Backbone Copper Cables:

1) Secure all backbone cables to wall within 12 inches (30.5 cm) of all terminations.
2) UTP backbone cables shall be installed in conduit, cable tray, on cable runway, or cable trough.
3) Cables above drywall ceilings shall be installed in conduit. Cables in exposed areas other than MER and TR shall be installed in conduit or surface raceway.
4) Cables shall not be allowed to lay on the ceiling slab or ceiling support structure. They must be anchored in such a way as to not interfere with other services or space access.

d. Optical Fiber Cable

1) All fiber cables shall be terminated with LC Duplex style connectors, multimode.
2) All fiber cables shall provide no more than 5 feet of spare cable at each end.
3) No splices will be acceptable in fiber cables, except for the installation of factory pigtails.
4) All fiber cables shall be neatly dressed and secured at racks and cabinets.
5) All pulls of fiber optic cable shall be made with a recording tension meter and breakaway swivel.
6) Where 250 micron coated fiber is field terminated, breakout kits that build up the fiber to a minimum 900 microns shall be used.

e. Inside Plant - Fiber:

1) Plenum and Riser Rated Optical Fiber Cables:

a) All fiber optic cable shall be installed in conduit innerduct, cable tray, on cable runway, or cable trough.

b) Maintain polarization for entire system as described in ANSI/EIA/TIA-568-B Section 12.7.1, or most current documentation.

c) Cable shall be continuous from patch panel to patch panel.

d) Leave a 5 feet service loop in the optical fiber runs within all telecommunications closets.

e) Adhere to all manufacturers' requirements regarding pulling tension and allowable lubricants.

f) The Contractor shall be responsible for verifying the actual lengths and distances.

g) The Contractor shall be responsible for verifying that conduits and raceways are "ready for occupancy" before cable placement.

h) The Contractor shall assume the responsibility for any difficulties or damage to the cable during placement.

i) Provide end caps on all optical fiber during installation.

J. Cross-Connect Installation

1. Termination and management hardware shall be installed in the following manner:

a. Cables shall be dressed and terminated in accordance with the recommendations made in the TIA/EIA-568-B document or most current documentation, manufacturer's recommendations and/or best industry practices.

b. Pair untwist at the termination shall not exceed .50 inch (1.27 cm).

c. Bend radius of the cable in the termination area shall not exceed 4 times the outside diameter of the cable.

d. Cables shall be neatly bundled and dressed to their respective panels. Each panel shall be fed by an individual bundle separated and dressed back to the point of cable entrance into the rack.

e. The cable jacket shall be maintained as close as possible to the termination point.

f. Each cable shall be clearly labeled where it can be viewed and properly associated with the termination, without the need to unbundle cables. Cables labeled within the bundle shall not be acceptable.

g. Fiber slack shall be neatly coiled within the fiber termination panel. No slack loops shall be allowed external to the fiber panel(s). Fiber cables shall be neatly bundled and dressed to their respective panels.

h. Each cable shall be clearly labeled within the enclosure so that the label can be viewed when the panel is opened. Cables labeled within the bundle shall not be acceptable.

i. Dust caps shall be installed on the connectors and couplings at all times unless physically connected.

3.3 GROUNDING

A. Comply with Division 16 Section "Grounding and Bonding for Electrical Systems".

B. Contractor shall furnish and install a minimum of one copper telecommunications grounding bus bar (TGB) per TIA/EIA 568B, 569A, and J-STD-607 standards, in each new telecommunications room or space.

C. Each TR shall use a copper stranded green insulated jumper interconnecting to the TMGB.

3.4 CABLE SYSTEM TESTING

A. Quality Assurance:

1. Comply with UL.
2. Comply with NFPA 70.
3. Comply with ANSI/TIA/EIA 568-B.
4. Tester Qualification: All personnel performing testing shall be trained and certified in the operation of the test equipment and in the analysis of the results, by the equipment manufacturer.
5. Testing Conference: Meet with the Owner's Representative on approval of the testing plan to develop a mutual understanding of the detail. Provide seven days advance notice of scheduled meeting time and location.

   a. Agenda Items: Include at least the following:

      1) Submittal distribution requirements.
      2) Contract documents examination report.
      3) Testing plan.
      4) Work schedule and project site access requirements.

5) Coordination and cooperation of trades and subcontractors.
6) Coordination of documentation and communication flow.

6. Certify the testing results for accuracy and compliance with the specifications.
7. Calibrate instruments at least every six months.

B. General:

1. All copper cables and termination hardware shall be 100% tested for defects in installation and to verify cable performance under installed conditions in compliance with TIA/EIA 568-B. All conductors of each installed cable shall be verified usable by the contractor prior to system acceptance. Any defect in the cable system installation including but not limited to cable, connectors, feedthrough couplers, patch panels, and connector blocks shall be repaired or replaced, at no cost to the Owner, in order to ensure 100% useable conductors in all cables installed.
2. Test leads for all tests shall be of the same manufacturer, grade, and type as the test subject.
3. Test instrument data shall be submitted in accordance with Division 1 requirements. In addition, all test instruments utilized on this project shall be consistent throughout the duration of the project and shall be turned over complete to the Owner upon completion.
4. All optical fiber cable strands and termination hardware shall be 100% tested for defects in installation and to verify cable performance under installed conditions in compliance with TIA/EIA 568-B. All strands of each installed cable shall be verified useable by the Contractor prior to system acceptance. Any defect in the cable system installation including, but not limited to, cable, connectors, feedthrough couplers, and patch panels shall be repaired or replaced, at no cost to the Owner, in order to ensure 100% useable strands in all cables installed.

C. Copper Cables:

1. Each cable shall be tested for continuity on all pairs and/or conductors. Twisted-pair data cables shall be tested for the all of the above requirements, plus tests that indicate installed cable performance. These data cables shall be tested using a Class I cable analyzer.
2. Each pair of each installed cable shall be tested using a "green light" test set that shows opens, shorts, polarity and pair-

reversals. The test shall be recorded as pass/fail as indicated by the test set in accordance with the manufacturers recommended procedures, and referenced to the appropriate cable identification number and circuit or pair number. Any faults in the wiring shall be corrected and the cable re-tested prior to final acceptance at no cost to the Owner.

3. Each installed cable shall be tested for installed length using a TDR type device. The cable length shall conform to the maximum distances set forth in the TIA/EIA-568-B Standard. Cable lengths shall be recorded, referencing the cable identification number and circuit or pair number.
4. High speed unshielded twisted pair (UTP) data cable shall be performance verified using an automated test set. This test set shall be capable of testing for the continuity and length parameters defined above, shall be performed Bi-directionally and provide results for the following tests:
   a. Near End Cross-Talk (NEXT)
   b. Attenuation
   c. Ambient Noise
   d. Attenuation to Cross-Talk Ratio (ACR)
   e. Power Sum NEXT
   f. Propagation Delay
   g. Propagation Delay Skew
   h. Power Sum ACR
   i. ELFEXT
   j. Power Sum ELFEXT
   k. Return Loss
5. Test results shall be automatically evaluated by the equipment, using the most up-to-date criteria from the TIA/EIA Standard, and the result shown as pass/fail. Test results shall be printed directly from the test unit or from a download file using an application from the test equipment manufacturer. The printed test results shall include all tests performed, the expected test result and the actual test result achieved. Hard and soft copies of the results shall be provided to the Owner in the format requested by the Owner.
6. Results which are marginal and cause ‘flags’ or other identifiers on the test results are unacceptable. These types of results are often

referred to as Pass* by test equipment manufacturers. Cable installations providing Pass* results shall be corrected as necessary without additional cost to the Owner.

D. Optical Fiber Cables

1. Each fiber strand shall be tested for attenuation with an optical power meter and light source. Cable length and splice attenuation shall be verified using an OTDR.
2. Multimode optical fiber attenuation shall be measured at 850 nanometers (nm) and 1300 nm using an LED light source and power meter. Tests shall be performed at both wavelengths on each strand of fiber. The set-up and test shall be conducted in accordance with EIA/TIA-526-14 Standard, Method B. Two meter patch cords shall be used as test references and for the actual test. This test method uses a one jumper reference, two jumper test to estimate the actual link loss of the installed cables plus two patch cords. Test evaluations for the panel to outlet (horizontal) shall be based on the values set forth in the EIA/TIA-568-B Annex H, Optical Fiber Link Performance Testing.
3. Singlemode optical fiber attenuation shall be measured at 1310 nm and 1550 nm using a laser light source and power meter. Tests shall be performed at both wavelengths in two directions on each strand of fiber for a total of four tests per strand. The setup and test shall be performed in accordance with EIA/TIA-526-7 Standard, Method 1A. Two meter patch cords shall be used as test references and for the actual test. This test method utilizes a one jumper reference, two jumper test to estimate the actual link loss of the installed cable plus two patch cords.
4. Test evaluation for the panel to panel (backbone) shall be based on the values set forth in the EIA/TIA-568-B Annex H, Optical Fiber Link Performance Testing.
5. Each strand shall be tested with an Optical Time Domain Reflectometer (OTDR) to verify installed cable length and splice losses. The OTDR measurements for length shall be performed in accordance with EIA/TIA-455-60. The measurements to determine splice loss shall be performed in accordance with manufacturers' recommendations and best industry practices.

6. Cable Tests:
   a. Test 1 - every strand shall be tested in one direction only, with an Optical Time Domain Reflectometer (OTDR) at a wavelength of 850 nm for multi-mode and 1310 nm for single-mode. The OTDR tests are to be printed out from the test equipment and delivered to the Owner with the other documents. This test can be performed utilizing a lab splice.
   b. Test 2 - each strand is to be tested with an Optical Time Domain Reflectometer (OTDR), at wavelengths of 850 nm and 1300 nm for multi-mode and 1310 nm and 1550 nm for single-mode. The OTDR tests are to be printed out from the test equipment and delivered to the Owner with the other documents.
   c. Test 3 - each strand is to be tested with an Optical Power Source (transmitter) and an Optical Power Meter (receiver) measured at wavelengths of 850 nm and 1300 nm for multi-mode and 1310 nm and 1550 nm for single-mode. The results of this test shall be recorded by the technician and delivered to the Owner with the other documents
7. Cable Testing - Pre Construction:
   a. Perform Test 1
   b. All strands of optical fiber cable shall be tested by the cabling contractor before it is installed. Every strand shall be tested with an Optical Time Domain Reflectometer (OTDR) at a wavelength of 1310 nm.
   c. If a single strand is found damaged, the cable will be considered a bad cable and must be replaced at no additional cost to the Owner.
8. Cable Testing - After Installation - Before Splicing or Termination: Perform Test 1
   a. All strands for each cable segment shall be tested after they are installed and before they are spliced
   b. If a single strand is found damaged, the cable will be considered a bad cable and must be replaced at no additional cost to the Owner.
   c. Test the new segment to demonstrate acceptability.
9. Cable Testing - After Splicing and Terminating:
   a. Perform Test 2
   b. Perform Test 3

c. If a single strand is found to exceed the performance criteria, the source of the problem must be identified and rectified or the cable will be considered a bad cable and must be replaced. The Owner shall not bear any additional expense to rectify the problem or to replace the cable.

d. The results of the above tests are to be certified reports, provided in both hard copy and soft copy format. The soft copy shall be accompanied by all software necessary to fully utilize the test results. Tests are to be witnessed by the owner's field representative and manually recorded.

e. Test results shall be organized in a manner that is acceptable to the Owner.

E. Patch Panels:

1. Patch panels shall be tested after horizontal cabling has been installed and terminated to both the panel and the work area outlet.
2. Panels shall be tested in the link or channel for DC continuity, NEXT, PSNEXT, Attenuation, Return Loss, ELFEXT, PSELFEXT using a Level II or Level III tester for Category 6.
3. A PASS indication shall be obtained for all link or channel tests when tested using the appropriate level tester for the appropriate category.

3.5 CABLE SYSTEM LABELING

A. General

1. This section describes the administration of cables, termination hardware, termination positions, and splices within the administrative jurisdiction. As changes are made to the wiring system, affected labels, records, reports, and drawings shall be updated.
2. Identical cables spliced together shall be administered as a single cable.
3. Termination hardware contains one or more termination positions. For example, an 8-pin modular connector on a panel may be administered as one termination position on its associated termination hardware.
4. This section describes the administration of the wiring hierarchy specified in ANSI/TIA/EIA-606A.
5. All labeling shall utilize machine generated characters. No hand written labels shall be accepted.

B. Identifiers

1. Cable Identifiers
   a. A unique identifier shall be assigned to each cable to serve as a link to the cable record. This identifier shall be marked on each cable or its labels.
2. Cable Labeling
   a. Horizontal and backbone subsystem cables shall be labeled at each end. Labels shall be affixed at each end rather than marking the cable. For proper administration. Additional cable labeling may be required on the cable at intermediate locations such as conduit ends, backbone splice points, manholes, and pull boxes. Both end termination positions shall be marked on the cable or its labels.
      1) Note - For hybrid cables, additional cable labels should be used to identify the individual hybrid components.
   b. Cables of differing conductor counts that are spliced together may be administered as separate cables. Encoded cable identifiers may be used to identify the pair/conductor counts of the largest cable. This method is preferable when splicing cables of dissimilar characteristics.
   c. The difference splice segments (branches) may be labeled with a single cable identifier provided that the pair/conductor count of the largest cable is maintained end-to-end and indicated on the cable labels.
   d. In the event that a cable is routed through multiple pathway segments, the pathway record linkage field shall contain references to all pathway segments used.
3. Termination Hardware Identifiers
   a. A unique identifier shall be assigned to each termination hardware unit to serve as a link to its record. For example C4R6 is termination hardware in column 4 row 6 of the backbone termination cross-connects in space B101.
   b. An identifier shall be marked on each termination hardware or its label.
      1) Note - Duplicate labeling of termination hardware located in the work area is optional. For example, a faceplate or box

does not require a separate identifier if the identifier for the connector is used for labeling.

4. Termination Position Identifiers
   a. A unique identifier shall be assigned to each termination position to serve as a link to the termination position record.
   b. An identifier shall be marked on each termination position label. Each termination position shall be marked with the termination identifier except in cases where high termination densities make labeling impractical. In these cases, identifiers shall be assigned to each termination hardware unit and to the actual termination position identifier determined by the conventions used for that unit. Labeling at the work area end may also include the termination position identifier for the other end of the cable and the cable identifier.
5. Splice Closure Identifiers
   a. A unique identifier shall be assigned to each splice closure to serve as a link to the splice record.
   b. An identifier shall be marked on each splice closure or its label.

C. Labeling and Color Coding
1. Labels
   a. Adhesive Labels
      1) Adhesive labels shall meet the legibility, defacement, and adhesion requirements specified in UL 969 (Ref D-16). Additionally, labels shall meet the general exposure requirements in UL 969 for indoor use. Outside plant labels shall meet the exposure requirements listed in UL 969 for indoor and outdoor use.
      2) Cable labels should have a durable substrate, such as vinyl, suitable for wrapping. Vinyl has good conformability, thereby making it desirable for wrapping and also enabling it to withstand bending. It is recommended to use labels with a white printing area and a clear “tail” that self-laminates the printed area when wrapped around a cable. The clear tail should be of sufficient length to wrap around the cable at least one and one-half times.

3) All characters shall be machine generated using a legible font large enough to read. All ink shall be permanent, non-fading, non-bleeding.

b. Insert Labels

1) Insert labels shall meet the legibility, defacement, and general exposure requirements specified in UL 969. Outside plant labels shall meet the exposure requirements listed in UL 969 for indoor and outdoor use. An insert label shall be securely held in place under the normal operating conditions and usage to which the labeled infrastructure element is subjected.

2) All characters shall be machine generated using a legible font large enough to read. All ink shall be permanent, non-fading, non-bleeding.

c. Pathway ID Tags

1) Each pathway, (conduit, cable tray, etc.), shall be appropriately tagged at both ends at strategic locations where midspans are accessible/visible.

2) Each tag shall be 2/32 inch (.16 cm) thick stainless steel, 2 inch (5.08 cm) to 2-1/2 inch (6.35 cm) in diameter, and include a 5/32 inch (.40 cm) hole for the fastener.

3) Authorized fasteners shall be wire-link chain or beaded chain.

4) Letters shall be stamped or engraved, 4/32 inch (.32 cm) high, and be consistent with the specified labeling scheme.

d. Rack Labels

1) Engraved, plastic laminated melamine, 3/32 inch (.24 cm) thick, engraved black letters on white face. Letters shall be 1/8 inch (.32 cm) high. Labels shall be attached utilizing stainless steel #10 screws at the top of the rack mounted on the front and back of the rack.

2. Color Coding of Termination Fields

a. Color coding as specified in this standard is based on the hierarchical star configuration for backbone cabling as specified in ANSI/TIA/EIA-568B. That standard allows a maximum of up to two hierarchical levels in the backbone. The first level in the hierarchy encompasses cabling from the main cross-connect to a telecommunications closet in the same building, or to an intermediate cross-connect in a remote building. The second

level encompasses cabling between two telecommunication rooms within the building containing the main cross-connect or between an intermediate cross-connect and a telecommunications closet in a remote building.

b. Color Coding Rules

1) termination labels identify the two ends of the same cable shall be of the same color;
2) cross-connections are generally made between termination fields (groups of termination labels) of two different colors;
3) the color orange (Pantone 150C) shall be reserved for the identification of the demarcation point (central office termination);
4) the color green (Pantone 353C) shall be used to identify the termination of network connections on the customer side of the demarcation point;
5) the color purple (Pantone 264C) shall be used to identify the termination of cables originating from common equipment (e.g., PBXs, computers, LANs, and multiplexers);
6) the color white shall be used to identify the first-level backbone telecommunications media termination in the building containing the main cross-connect;
7) the color gray (Pantone 422C) shall be used to identify the second-level backbone telecommunications media termination in the building containing the main cross-connect;
8) the color blue (Pantone 291C) shall be used to identify the termination of station telecommunication media and is required only on the TC and ER end of the cable, not at the telecommunications outlet;
9) the color brown (Pantone 465C) shall be used to identify interbuilding backbone cable terminations;
10) the color yellow (Pantone 101C) shall be used to identify the termination of auxiliary circuits, alarms, maintenance, security, and other miscellaneous circuits;
11) the color red (Pantone 184C) shall be used to identify the termination of key telephone systems;
12) in buildings not containing the main cross-connect, white may be used to identify second-level backbone terminations.

D. Records

1. General

a. For effective administration, telecommunications records are typically used in conjunction with other records. The data included in the records shall contain specific information about the particular installation as required, such as component manufacturer, transmission rate, etc.

2. Cable Records

a. The cable identifier, cable type, and unterminated, damaged, available pairs/conductors shall be recorded for each cable. Additionally, linkages to termination position records, splice records, pathway records, and grounding records shall be maintained. The cable record shall document every pair/conductor in the cable.

b. The cable type field shall include the manufacturer and manufacturer’s designation. The month and year of installation or acceptance shall also be recorded.

c. The termination position linkage field is used to document the termination positions of every pair/conductor or set of pairs/conductors of the cable. Each pair/conductor or set of pairs/conductors has a linkage to two termination position records.

d. The pathway from each outlet to head-end equipment shall be identified on record plans.

3. Termination Hardware Records

a. The termination hardware identifier and type, and damaged position numbers shall be recorded for each element of termination hardware. Additionally, linkages to termination position records, space records, and grounding records shall be maintained. The termination hardware record shall identify every termination position within the hardware.

b. Termination position linkage fields are used to provide access to information in termination position records. Termination positions may be used individually or in sets.

4. Termination Position Records

a. The termination position identifier type, user code, and cable pair/conductor numbers shall be recorded. Additionally, linkages

to cable records, termination position records, termination hardware records, and space records shall be maintained.

b. Other termination position record 1 linkage is used to document the corresponding termination position at the other end of the pair or sets of pairs. Other termination position record 2 linkage is used to document the cross-connect position.

c. A user code shall be assigned to a termination position record for a telecommunications outlet connector only. This user code may be a telephone number, circuit number, user name, or some other specific term of reference.

5. Splice Records

a. The splice identifier and type shall be recorded. Additionally, linkages to cable records and space records shall be maintained.

b. To administer slices joining cable segments with one cable identifier (singly administered), a linkage is established from the cable record to the splice record through the splice linkage field.

c. To administer splices joining cable segments with separate cable identifiers (separately administered), a pair/conductor-level linkage is established from the cable records to the splice record through the termination position field.

E. Reports

1. Cable Reports

a. A cable summary report shall be available listing all cables and, at a minimum, their type and terminating positions. Additional information from the cable records or other interlinked records may be desirable.

2. End-to-End Circuit Report

a. The end-to-end circuit report traces connectivity from end to end. At a minimum, the report should list a user code, associated termination positions, and cables establishing connectivity from the work area to the other end of each circuit. Additional information from termination position or other interlinked records may be desirable.

3. Cross-Connect Report

a. Each termination space containing cross-connects shall have a report available listing the cross-connections in that space.

Additional information from the termination position records or other interlinked records may be desirable.

3.6 CLEANING

A. On completion of system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

3.7 WARRANTY

A. The installing contractor shall facilitate a manufacturer's warranty between the manufacturer and the Owner which provides coverage of the installed cabling system for twenty years. An extended component warranty shall be provided which warrants the functionality of all components used in the system for twenty years from the date of registration along with a twenty year performance warranty for the horizontal cable plant.

B. At a minimum, the warranty shall define the following:

1. That all passive components (those exhibiting no gain or energy contribution) comprising the registered solution will be free from manufacturing defects in material and workmanship under normal and proper use.
2. That all cabling components utilized in the registered solution exceed the specifications of the TIA/EIA 568-B and ISO/IEC IS 11801 standards.
3. That the installation will exceed the attenuation, near end crosstalk (NEXT), and power sum requirements of TIA/EIA Bulletin 568-A and ISO/IEC IS 11801 for cabling links and channels.
4. That the installation will exceed the loss and bandwidth requirements set forth in of TIA/EIA Bulletin 568-B and ISO/IEC IS 11801 for fiber links and channels.
5. That the registered solution will be free from failures which prevent operation of any current or future applications introduced by recognized standards or user forums that use the TIA/EIA 568-B and ISO/IEC IS 11801 component and link/channel performance specifications.

C. The warranty shall include all parts and labor necessary.

D. The warranty shall apply to the “LINK” as defined by TIA/EIA. B “CHANNEL” warranty is not applicable.

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