SECTION 16746 - TELECOMMUNICATIONS SYSTEM

GENERAL

1.1 SECTION INCLUDES

A. This section of the specification includes the furnishing, installation, connection and testing of a complete Structured Cabling System (SCS). The SCS is defined as all required equipment and cabling including hardware, termination blocks, cross connect wire, patch panels, patch cords, voice and data network outlets, work area cords, and UTP installed and configured to provide a computer data connectivity from each data network device to the network file server or network/switch designated as the service points of the local area network as well as from each voice device to the Owner's telephone system controller. Provide all equipment required to form a complete, operative, and coordinated system as shown on the drawings and specified herein. Components of the SCS shall include, but are not limited to, the following:

1. Telecommunications equipment racks.
2. Telecommunications patch panels.
3. Telecommunications data network and voice outlet jacks.
4. Intra-building telecommunications cable.
5. Data network and voice patch cords.
6. Cable TV cable and outlet jacks.

1.2 RELATED SECTIONS

A. Section 16010 - Electrical General Requirements.

B. Section 16111 – Conduit.

C. Section 16130 - Boxes.

D. Section 16195 - Electrical Identification.

E. Section 16450 – Grounding.

1.3 REFERENCES

A. ANSI/EIA/TIA No. 568A - Telecommunications Wiring Standards

B. ANSI/EIA/TIA No. 569 - Telecommunications Pathways and Spaces

C. ANSI/EIA/TIA No. 606 - The Administration Standard For the Telecommunications Infrastructure

D. ANSI/EIA/TIA No. 607 - Grounding/Bonding

E. EIA/TIA TSB-36 - Additional Cable Specifications For Unshielded Twisted Pair cables

F. EIA/TIA TSB-40 - Additional Cable Specifications For Unshielded Twisted Pair Connecting Hardware

G. EIA/TIA SP-4195 ANSI/TIA/EIA-568A-5 - Transmission Performance Specifications For Enhanced Category 5E Twisted Pair Cabling Systems

1.4 QUALIFICATIONS

A. Installer: Company specializing in the installation of telecommunications systems, including installation and certification of "Enhanced Category 5" cabling. Company shall have three (3) years (minimum) documented experience on completed projects. All work shall be performed and supervised by telecommunications technicians who are qualified to install voice, data and image cabling systems and to perform related tests. The telecommunications technicians employed shall be fully trained and qualified by the manufacturer of the test equipment for the installation. Evidence that the Contractor is a current certified installer of the manufacturer must be provided in writing prior to commencing work.

B. System: The cabling system shall conform to the current of industry standard ANSI/TIA/EIA 568A. Certification shall be provided that the system will support applications for which it is designed including enhanced Category 5 intra-building telecommunications cable performance.

1.5 QUALITY ASSURANCE

A. Contractor Quality Assurance:
1. Provision of all manufactured components, installation, wiring, and testing shall be the responsibility of a single contractor.
2. Maintain the same person in charge of work throughout installation.
3. Supply and install any incidental equipment needed in order to result in a complete and operable system.
4. Verify correctness of parts lists and equipment model numbers and conformance of each component with manufacturer's specifications.
5. Unless otherwise specified, supply only new equipment, parts and material, and operate only as required for testing as part of installation procedure.

B. Manufacturer Quality Control for Telecommunications Data Network Systems: All systems components and products specified shall be supplied by a single manufacturer or certified by an independent testing laboratory as a complete system with different manufacturer's components, with the exception of data racks and other hardware that is not defined as part of the channel test configuration by TIA/EIA TSB67, Transmission Performance Specifications for Field Testing of unshielded Twisted-Pair Cabling Systems and shall be as specified herein. Unless the words "Or Approved Equal" are included, only the manufacturers listed will be considered.

C. Each system is to be fully tested upon completion of installation in accordance with PART 3 - EXECUTION of this specification.

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 1 and Section 16010.

B. Shop Drawings and Product Data: Submit complete and at one time. Provide manufacturer's catalog information showing dimensions, colors, and configurations. Isolated items will not be considered for approval, except by prior authorization.

C. A technical data sheet from the manufacturer should be included with the response for each product proposed. This data sheet shall include the physical specifications as well as the following electrical and transmission characteristics: Mutual Capacitance; Impedance; DC Resistance; Attenuation; Worst Pair-to Pair Near End Crosstalk; Power Sum Near End Crosstalk.

1.7 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 16010.

B. Accurately record location of data processing outlets.

C. Accurately record location of cable TV outlets.

1.8 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Route wire and cable as required to meet Project Conditions. Include wire and cable lengths within 10 feet of length shown for all local data outlets.

C. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 16010.

B. Include operating instructions, and maintenance and repair procedures.

PRODUCTS

2.1 TELECOMMUNICATIONS FLOOR RACK

A. Manufacturer:
1. *Hubbell*.
2. *Chatsworth*
3. *PFT*.
4. Substitutions: Or approved equal.

B. Free Standing Equipment Racks: Free standing equipment racks shall be seven feet (2134mm) high, EIA nineteen inches (518mm) wide, fifteen inches (381mm) deep, open bay as indicated on the Drawings. Rack features shall include the following:
1. Universal hole pattern on the front and rear flanges, and mounting holes on both sides of rack assembly for management brackets.

2. Racks shall be extruded (not sheet metal) with 10 - 32 threaded equipment mounting holes. Mounting holes that require supplemental threaded clips are specifically prohibited.
3. Shelves for electronic equipment with load carrying capacity to support at least 125 percent of each piece of electronic equipment weight. Shelves shall have adequate openings within them to dissipate heat and allow for adequate electronic equipment ventilation.
4. Mounting brackets specifically designed to support the equipment installed within the rack.
5. Hook and loop (Velcro) cable strain relief system on rear of rack to support horizontal and backbone cables. Tie-wraps are specifically prohibited.
6. Hook and loop (Velcro) horizontal and vertical cable management on front of rack for dressing patch cable and cross connect wiring. Tie-wraps are specifically prohibited.
7. Hook and loop (Velcro) cable management system independent of telecommunications cabling management to properly dress the electronic equipment power cords through the rack maintaining as much clearances between the two as possible. Tie-wraps are specifically prohibited.
8. Bonding and grounding cables for all equipment not directly bolted to equipment rack (i.e shelf-mounted electronic equipment, etc.).
9. Bonding and grounding bus bar with individual set screw terminals for at least a minimum of six #6 Cu. bonding cables.
10. Surge protected power strip as described in this specification.
11. Patch panels as described in this specification.
12. All hardware, supplementary steel, channel and supports as required to properly assemble the rack and support it to the building structure.

2.2 TELECOMMUNICATIONS WALL RACK

A. Manufacturers:
   1. *Blackbox* model RM336A/RM250
   2. Substitutions: Or approved equal.

B. Wall-Mounted Cabinet Racks: 48” high hinged, swing-out cabinet with a 19” high equipment rack. Cabinet shall be constructed of heavy-duty 14 and 16 gauge steel. Cabinets shall be equipped with adjustable mounting rails, a locking front door, louvered side panels and an integral fan.

2.3 PATCH PANELS - CAT 5E

A. Manufacturer:
   1. Amp
   2. Panduit
   3. Hubbell
   4. MOD-TAP
   5. Ortronics

B. Attenuation and Cross Talk Values:
   1. Modular jack contact wires: 50μ of hard gold over nickel (or equivalent).
   2. Mod. Jack contact pressure: 100 grams, minimum, per contact.

2.4 PATCH PANELS – FIBER OPTIC CABLING

A. Manufacturer:
1. MOD-TAP
2. Ortronics
3. Siecor

B. Description: Patch panels shall be capable of terminating 12-pair (24 strands) of a fiber optic cable. Patch panels shall be rack-mounted 1.75" (44mm) high EIA, 19" (518mm) wide, drawer-type with integral cable management, pre-loaded with duplex SC couplings.

2.5 CABLE TELEVISION OUTLET BOXES

A. Outlet Boxes: Sheet metal, as specified in Section 16130.

2.6 TELECOMMUNICATIONS OUTLET JACKS

A. Manufacturer:
1. Amp
2. Panduit
3. Hubbell

B. Data Network Jack Outlet: 8-position duplex modular type jack suitable to accept multi-position modular plugs (quick connect terminals). Jacks shall be suitable for back wiring and mounting in a standard electrical box. Jacks shall conform to UL 1863 and ANSI/TIA/EIA 568A. Jacks shall include a plastic ivory faceplate and mounting lugs.
1. PIN/ PAIR assignment - Wiring shall be terminated on the 8-position modular jack to PIN/ PAIR assignment for UTP cabling. Confirm PIN/PAIR assignment with Owner's Network Coordinator prior to beginning any work.
2. Outlet color: Gray

C. Voice Outlet: 6-position single modular-type jack suitable to accept modular RJ25 plugs (quick connect terminals). Jack shall be suitable for back wiring and mounting in a standard electrical box. Jacks shall include a plastic ivory faceplate and mounting lugs.
1. Outlet color: Ivory.

D. Outlet Configuration: Data network and voice outlets, where show on the plans in a side-by-side location, may be combined with a single faceplate and a 2-gang box.

2.7 CABLE TELEVISION JACKS

A. Recessed Wall Type: "F" style threaded coaxial cable connector suitable for back wiring and mounting in a standard electrical box. Jack shall include a plastic ivory faceplate and mounting lugs.

2.8 INTRA-BUILDING TELECOMMUNICATIONS CABLE

A. Manufacturer:

1. AMP
2. Mohawk
3. Superior
4. General Cable
5. CommScope

B. Description: Category 5E unshielded twisted 4-pair wiring (UTP), 24 AWG. Category 5E cable shall meet the physical requirements of ANSI/ICEA publication S-80-576 (ref. B1.6). Cable shall be tested to minimum 350mHz. Exterior jacket color shall be blue,

C. Characteristics at 20 °C:
1. Nominal Impedance: 100 ½ ± 15% (from 1MHz to 100 MHz)
2. Maximum DC Resistance: 9.38 ½ / 100m
3. Mutual Capacitance (max.): 5.25 nF/100m

2.9 FIBER OPTIC BACKBONE CABLE

A. Multimode Fiber Optic Cable: Cable shall be NRTL certified to TIA/EIA492CAAA, 492AAAA EIA/TIA 568B Series standard, TSB72 and ANSI XeT9.5 fiber optic specifications, 50/125 micron, 1300 nm, graded video, dual-window 6-pair (12 strand) tight-buffer, multimode distribution cable.
1. Riser-rated multi-mode cable – OFNR jacket, distribution cable for riser applications.
2. Plenum-rated, multi-mode cable – OFNP jacket, distribution cable for plenum applications.
3. The maximum attenuation measured at 23 degrees C, 3.75 dB/km @ 850 nm and 1.5 dB/km @ 1300 nm. The minimum bandwidth shall be 160 MHZ @ 850 nm and 500MHZ @ 1300nm.

2.10 PATCH CORDS

A. Manufacturer:
1. AMP
2. Mohawk
3. Superior
4. General Cable
5. CommScope

B. Category 5E unshielded, twisted-pair (UTP) modular line cords with # 24 AWG thermoplastic insulated solid conductors formed into 4 individually twisted pairs and enclosed in a thermoplastic jacket. Line cord shall be terminated with 8-position modular plugs at both ends, conforming to ANSI/TIA/EIA 568A. Line cords shall not exceed 3m in length. Patch cords shall be factory assembled and tested. Provide twenty-four, 1-meter long patch cords.
1. Characteristics at 20 °C: Match manufacturer and characteristics requirements for intra-building telecommunications cable.

C. Fiber Optic Patch Cables:
1. Provide NRTL certified EIA/TIA 492AAAA, EIA/TIA 568B Series standard performance tested patch cables as required for a complete operational system. Patch cables shall be factory pre-connectorized, two strand, "SC" type connectors, tight-buffer.

Patch cables connectors shall be provided by the same manufacturers as the fiber optic connectors and couplings.

2. Patch cables shall match the fiber optic system installed, multimode 50/125 micron.
3. One strand of the patch cable shall have a distinguishing mark throughout its entire length to simplify the distinction between Transmitting (Tx) and Receiving (Rx) at the patching area. Color-coded factory marked (Tx-Rx) connectors are preferred.

2.11 INTERIOR CABLE TELEVISION WIRING

A. Manufacturers:
1. *Belden*.
2. *AT & T*.
3. Substitutions: Or Approved Equal.

B. Description: Coax cable, 60 degrees C, RG-6 for circuit runs 300 feet and less. Coaxial cable, 60 degrees C, RG-11 for circuits longer than 300 feet and for service distribution cable from service entrance to distribution patch panel.

2.12 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A. Manufacturers:
1. *APC - American Power Conversion*.
2. *Best*.
3. Description: Provide a 500 VA rack mounted UPS for each telecommunications rack provided in the project.

2.13 CABLE SUPPORTS

A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:

J-Hooks:	Caddy, Chatsworth, Mono-System.
Hook and Loop Fasteners:	Chatsworth, Ortronics, Siemons.
Cable Ties:	DEK, Panduit, Amp, 3M, T&B.
Beam Clamps:	Burndy, Minerallac, Kindorff, Steel City, OZ/Gedney.
Split Mesh Strain Reliefs (Kellums):	Hubbell, Woodhead.

A. Hooks shall be sized to correctly support the number of cables that pass through them. Under no circumstances shall cable quantity exceed 14 in any given support unless ceiling spaces affected are to be sprinklered. Fill capacity shall be as required by code for conduit. That is to say that every J-Hook shall have a maximum of 40 percent fill capacity. Install additional supports as required.

B. Hook and loop fasteners shall be designed for their specific application. For example, if a hook and loop fastener is used to support cables to a rack, it shall have a grommeted outlet for use with a 10-32 rack mounting screw.

C. Cable-ties shall be correctly sized to support the quantity and types of cables installed.

D. Beam clamps shall be steel with threaded bolt type closure. Spring steel or "quick-clip" type clamps are prohibited.

E. Split mesh strain reliefs shall be properly sized for each cable that they support. Only one cable shall be installed in each split mesh strain relief.

2.2 BONDING AND GROUNDING JUMPER

A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:
1. *Belden* (No. 8669)

B. Jumper cable shall be hollow braided, 60 amp capacity, copper.

C. Jumpers shall have compression or exothermic type terminals on both ends of cables. Terminals shall be compatible with jumper cable material and equipment material in order to not have any degenerative reaction.

2.3 CROSS CONNECT BLOCKS

A. Manufacturer:
1. AMP
2. Hubbell
3. Panduit

B. Description: Cross connect blocks with a minimum of twelve (12) 8-position ports and a 50-pair capacity. Blocks shall be rated CAT5E.

EXECUTION

3.1 GENERAL

A. Verify the exact location prior to bid of all items that may be indicated and determine exact location of all electrical items that are not indicated on the Drawings.

B. Do not install equipment and materials that have not been reviewed by the Resident. Equipment and materials that are installed without the Resident review or without complying to comments issued with the review shall be removed from the project when so instructed by the Resident. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.

C. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.

D. Equipment and systems shall not be installed without first coordinating the location and

installation of equipment and systems with the General Contractor and all other Trades.

E. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.

F. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.

G. After installation, equipment shall be protected to prevent damage during the construction period. Openings in boxes shall be closed to prevent the entrance of foreign materials.

H. Home runs indicated are not to be combined or reduced without written consent from the Resident.

I. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.

3.2 WORK

A. Any ceilings, walls, floors, furniture, equipment, furnishings, etc., damaged by the work of this Section shall be replaced, or at the Owner's option, repaired with similar materials, workmanship and quality.

B. Work includes field survey of existing conditions, systems, equipment and tracing of existing circuits in order to determine scope of work.

3.3 EQUIPMENT RACKS

A. Securely mount wall equipment rack to the building structure. Proper supports such as 3/8" lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Drywall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.

B. Position racks, cabinets and wall mounted relay brackets in order to have minimum 3-foot clearance for easy access. Equipment rack cabinets shall have 3-foot clearance in front of deepest component.

C. Install terminating components such as patch panels (UTP); cable management, etc. into the rack cabinet.

D. Patch Panels: Mount patch panels onto the rack at the top of the rack.

E. Cable Management: Secure the cable bundle(s) to the rack strain relief and wire management behind the patch panel. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.

F. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.

G. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions.

3.4 OUTLET JACKS

A. Work Area Outlets installed in casework shall have their cables installed within the conduit provided or raceway provided.

B. Outlets shall be seated properly and shall be installed level on walls and parallel to building elements as required.

3.5 CABLE TELEVISION JACKS

A. Recessed Wall Type: "F" style threaded coaxial cable connector suitable for back wiring and mounting in a standard electrical box. Jack shall include a plastic ivory faceplate and mounting lugs.

3.6 TERMINATIONS

A. All conductors of every cable shall be completely terminated at both ends.

3.7 CABLE PATHWAYS

A. Provide all equipment and cabling for a complete installed operating system.

B. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.

C. All cabling shall be installed concealed within partitions or above ceilings and shall be supported from the building structure (e.g. J-Hooks, etc.).

D. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other the minimal number of times as required due to building design limitations.

E. Clearances: Clearances between cabling and other building systems as required by EIA/TIA 569 and BICSI shall be maintained throughout the building.

F. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.

G. Provide expansion fittings and adequate cable slack at all building expansion joints.

3.8 SMOKE AND FIRE STOPPING SEALS

A. Smoke and Fire Stopping Seals: Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation or air handling ducts so that the spread of fire or products of combustion shall not be substantially increased.

1. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be fire stopped using approved methods and NRTL listed products to maintain the fire resistance rating.
2. Installation restrictions of the listing agencies shall be strictly adhered to (e.g. 24 inch (610 mm) minimum horizontal separation between boxes on opposite sides of the wall, maximum square inch opening in wall).
3. Fire stopping in sleeves or in areas having small openings that may require the addition or modification of installed cables or raceways shall be a soft, pliable, non-hardening fire stop putty. Putty shall be water resistant and intumescent.
4. Fire stopping in locations not likely to require frequent modification shall be a NRTL listed putty or caulk to meet the required fire resistance rating.
5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.
6. Fire stopping of cable trays through walls shall be with NRTL listed bags to meet the required fire resistive rating and that will not allow products of combustion to pass through the protected opening. The NRTL listed bags shall be installed inside and on both sides of the opening as required to meet the required resistive fire rating of the wall.
7. Fire stopping materials shall be NRTL listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL fire stopping system. Submit specifications and installation drawings for the type of material to be used. Fire stopping materials shall be as manufactured by *3M, International Protective Coatings Corp., Specified Technologies, Inc., Carborundum Company, RayChem, Nelson Fire Stop* or approved equal.

3.9 CABLE SUPPORTS

A. Provide cable ties at equipment rack.

B. Cable ties or hook and loop (Velcro®) cable wraps for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal transmission rating (geometry) of the cable. Hook and loop (Velcro®) cable wraps only shall be used in lieu of cable ties for cables only.

C. When pathways are not provided or specified, provide strap supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be five feet (1 500mm) depending on the structural elements of the building. Maximum number of cables per support shall be fourteen. Provide additional supports as to maintain required bending radius of cables.

D. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, ductwork, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by Room.

3.10 CABLE PROTECTION

A. Protect all cables during construction. Cables damaged during installation shall not be repaired.

They shall be completely replaced with new cable.

B. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two-piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.

C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.

D. Fiber optic backbone cables shall be installed in inner duct.

E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.11 INSTALLATION

A. All cabling shall be concealed within partitions or above ceilings. Install cabling in conduit from device box to space above closest accessible ceiling. Install cabling in conduit where located above gypsum board ceilings.

B. Splices, Taps, and Terminations: Make splices, taps and terminations on numbered terminal punch blocks in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.

C. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

3.12 LABELING

A. Labeling procedure shall meet EIA/TIA 568B Series standard and 606 and BICSI Standards and shall be pre-approved by the Resident. Hand-written and embossed type labels are specifically prohibited.

B. Permanently label, using pre-printed labels, all cables and terminations exactly as defined herein:
1. Label each equipment rack and cabinet.
2. Label patch panels and cross connect blocks numerically, top-to-bottom.
3. Label patch panel and cross connect blocks ports numerically.
4. Label the cable segments as indicated on Drawing Schedules. Each outlet will be designated by the incoming cable, and will be labeled accordingly.
5. Label each equipment rack, panel and cross connect block uniquely.
6. Refer to Administration section for specific labeling requirements.

C. Use industry standard EIA/TIA and BICSI color codes as specified herein and maintain consistent color-coding throughout the building.

3.13 UTP CABLING SYSTEMS

A. The general topology shall be a "hierarchal star" configuration. All segments shall originate in NRTL listed patch panels located in the telecommunication equipment racks/cabinets and end at the Work Area Outlet.

B. Routing
1. Route cables (minimum of 12 inches (305mm) away) to avoid light ballasts, transformers, power wiring and other electrical devices so that there is no EMI or RFI interference with data transmission.
2. Cable routes shall be with 90 degree angles whenever possible. Cables shall not be installed randomly or diagonally through the building.

C. All cables shall have both ends completely terminated at their respective patch panel and Outlet Jacks. Individual conductors shall be trimmed flush with IDC block. Cables indicated to be "spare" shall have one end terminated at their respective patch panel or cross-connect block and the other end shall be hermetically sealed with a polyolefin heat-shrinkable cap. Provide *RayChem Co*. or approved equivalent after testing. Tape shall not be approved.

D. The total length of permanently installed cable for any complete segment shall not exceed 295 feet (90m). Do not splice or otherwise re-terminate any cable used, terminate only at the patch panels, cross connect blocks and Outlet Jacks. Route cables (minimum of 12 inches (305mm) away) to avoid light ballasts, transformers, power wiring and other electrical devices so that there is no EMI or RFI interference with data transmission. Permanently label all cables six inches from the connector at each end, according to the numbering convention outlined in the section on labeling. All cables shall be terminated at outlets, patch panels or cross connect blocks Only.

E. Maximum pulling tension shall not exceed 25 lbs/ft. when installing cables.

F. Modular Jacks: Each voice and data network jack shall have a Category 5E home cable run back to its associated patch panel.

3.14 FIBER OPTIC CABLING SYSTEMS

A. Cabling
1. The general topology shall be star configuration. All segments shall originate from NRTL listed fiber optic patch panels located in equipment rack/cabinet and be distributed to fiber optic patch panels in next equipment rack/cabinet.
2. All 12 strands within the fiber optic backbone cable shall have both ends terminated in their respective patch panels. "Dark" fibers are not allowed.
3. All fibers supplied in cable shall be usable fibers and meet required specifications. "Spare" unspecified fibers shall not be allowed.
4. Multimode fiber optic cable: Multimode fiber optic cable shall be furnished and installed from the main cross-connect to each equipment rack/cabinet.
5. Pulling tension shall not exceed 25 lbs/ft when installing cables.
6. Fiber Optic Cable Management:
   a. Hook and loop (Velcro) type cable wraps shall be secured with minimum required compression in order to secure cables properly without impeding the signal transmission rating (geometry) of the cable. Cable ties are strictly prohibited.
   b. Split mesh metal strain reliefs (Kellums) shall be provided to secure cables installed vertically.
   c. Fiber Optic Patch Panels:
      (1) Provide silk screening on panel to distinctly identify transmit (Tx) and

receive (Rx) at each port. Provide large bold label indicating information similar to **"CAUTION - SEVERE EYE DAMAGE! DO NOT LOOK INTO FIBER OPTIC CONNECTOR WHILE ENERGIZED!"** and mount signage to the fiber optic patch panel.

(2) Final connection of patch cables is provided under this Section.

d. Inner Duct:

(1) All fiber optic cabling shall be installed in inner duct.

(2) Provide 1 $^{1}/_{4}$ inch inner ducts with 200-pound-test pull line, above ceilings through the building from one equipment rack/cabinet to the next rack/equipment.

3.15 PATCH PANELS AND PATCH CORDS

A. Provide sufficient quantities of Category 5E patch panels in each wire center (MDF, IDF) to allow for twenty percent (20%) growth.

B. Provide patch cables as follows:

1. Provide one UTP patch cable for each horizontal cable terminated within the patch panel.
2. Provide 12 duplex SC Fiber optic patch cables at each Fiber optic patch panel.
3. Patch cable lengths shall be field measured before ordering.

3.16 GROUNDING

A. General:

1. The Telecommunications systems comprising of equipment cabinet, rack and non-current carrying metallic parts shall be grounded according to the Electrical Code.
2. In general, the grounding shall be as specified, as specified and as required by the Electrical Code and Local Authorities.

B. Methods:

1. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
2. The installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground buss bar.

3.17 SLEEVES AND BUSHINGS

A. Raceways and openings shall be laid out in advance to permit their provision in the work. Sleeves and raceway shall be set before new masonry is constructed. Any extra work required where sleeves or raceways have been omitted or improperly placed shall be performed at the expense of the Installer that made the error or omission, including coring.

1. Existing Construction: Where raceways and cable pathways must pass vertically through existing construction, coring shall be located as per the guidelines shown on the drawings.

B. Provide sleeves for raceways, busways and cable trays penetrating floors, fire walls, or smoke partitions. Install approved material to provide for fire stop.

C. Provide waterproof seals inside and outside raceway when penetrating from the exterior or underground.

D. Except where specified otherwise sleeves shall be made of galvanized metal to finish flush with building finish lines.

E. Provide acoustic sealer in sleeves between occupied spaces.

F. Sleeves installed in floors shall extend two inches (50mm) above the finished floor unless specifically indicated otherwise. Sleeves for busways shall extend four inches (100mm) above the floor.

G. Provide sleeves in masonry construction and in full height (slab to slab) walls.

H. Provide sleeves for any openings requiring fireproofing.

I. Bushings in all conduits shall be provided by the Electrical Subcontractor in all metal studs and other openings where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.

3.18 TELECOMMUNICATIONS SYSTEMS TESTING

A. Cabling systems shall meet or exceed the electrical and transmission characteristics of the systems specified.

B. Cable segments and links shall be tested from both ends of the cable for each of the construction phases. (Verify that cable labeling matches at both ends).

C. Test Reports: Upon completion and testing of the installed system for each of the construction phases, test reports shall be submitted in booklet form showing all factory and field tests performed. Organize test reports by each telecommunication closet. Test reports shall be typewritten. Provide documentation and a copy of the standards being tested to. Indicate where test is in compliance, and acceptable limits for the test, measured value of the test and application involved. Submit test report formats for approval during shop drawing review.

D. The system shall not be considered certified until the tester has acknowledged, in writing, that the performance of the physical layer of the system has been fully tested and is operational at the completion of the installation phase.

E. Equipment Manufacturer's Factory Test
1. Each cable and equipment manufacturer shall factory test their respective products being installed on this project and provide test reports at time of delivery. Provide separate respective test reports indicating that they meet or exceed the latest applicable TIA/EIA Standards and technical bulletins.
2. All other products relative to this specification shall be tested to its respective industry strictest standards.
3. Each manufacturer shall factory test their respective cable or equipment provided to this

project at several lower frequency levels, including the minimum and maximum frequency level indicated herein. The test reports shall indicate test results for at least five equal incremental frequency levels including the maximum required.

F. Field Testing Equipment: Submit during shop drawing review on the testing equipment to be utilized on this project. The installer shall test all cables installed under this Section. Provide a hard copy of all field-testing.
   1. Unshielded and Shielded twisted pair Testing Equipment: The cable tester shall have a wide variety of preprogrammed cable types as an integral part of its testing system and have the ability to test cables less than 6 feet (6ft.) from the test point.
      a. Cable tester shall be NRTL certified for EIA/TIA TSB95.
   2. Fiber Optic Test Equipment: Cable testers shall be Optical Power Meter and High Resolution Optical Time Domain Reflectometer (OTDR) The cable tester shall be NRTL certified for compliance to latest EIA/TIA 568B Series standard and TSB72 performance requirements, at 850, 1300 and 1550 nm

G. UTP Cabling Systems
   1. Test each UTP cable and passive components. Provide certification that entire installation of UTP cabling, equipment and jacks are NRTL certified meeting or exceeding a minimum of category performance specified on all four pairs of conductors. Tests shall indicate each cable segment performance as well as each cable overall channel performance (includes patch cables at both ends of cable segments).
   2. Tests shall be based on each pair of conductors and not the aggregate multiple pair results.
   3. UTP Cable: Test all installed cable segments end-to-end, from the horizontal patch panel to each Work Area Outlet with a Signal Injector, Graphical Link Testing Meter and Time Domain Reflectometer (TDR) for compliance to latest EIA/TIA performance requirements, as well as NEXT, ELFEXT, structural return loss, alternating power sum, opens, shorts, continuity, cable length, and Characteristic Impedance.
   4. Test results shall include:
      a. Wire Map
      b. Length
      c. Attenuation
      d. Near-end Crosstalk (NEXT) Loss
      e. NEXT (Near End Cross Talk)
      f. PS-NEXT (Power Sum Near End Cross Talk)
      g. ELFEXT (Equal Level Far End Cross Talk)
      h. PS-ELFEXT (Power Sum Equal Level Far End Cross Talk)
      i. Propagation Delay
      j. Delay Skew
      k. Impedance
      l. Return loss
      m. Wire map will determine the following:
         (1) Continuity to the remote end
         (2) Shorts between any two or more conductors
         (3) Crossed pairs
         (4) Reversed pairs
         (5) Split pairs
         (6) Any other mis-wiring

n. Below are the current testing requirements in addition to the basic wire-map and length tests for Category 5E cables and the respected limits for each test parameter.

(1)	Attenuation	21.6 dB Link – 24.0 dB Channel
(2)	NEXT	32.3 dB Link – 30.1 dB Channel
(3)	PS-NEXT	29.3 dB Link – 27.1 dB Channel
(4)	ELFEXT	20.0 dB Link – 17.4 dB Channel
(5)	PS-ELFEXT	17.0 dB Link – 14.4 dB Channel
(6)	Return Loss	21.1 dB Link – 10.0 dB Channel
(7)	Prop. Delay	510 ns Link – 548 ns Channel
(8)	Delay Skew	45 ns – 50 ns Channel

5. Length is determined by the propagation of delay of signals and depends on the twist helix and dielectric materials. Note: Calibration of nominal velocity of Propagation (NVP) is critical to the accuracy of the length measurements when estimating from either frequency or time domain methods.
   a. The maximum physical lengths for:
      (1) Basic link = 94 meters including test equipment cords.
      (2) Channel = 100 meters including equipment cords and patch cords.
      (3) Test results shall be reported in feet.
6. Attenuation: Link attenuation shall include all connection hardware.
7. Near end Cross Talk (NEXT) Loss: Next and PS-NEXT shall be measured form both ends of the cable or link under test. For accurate measurements, at least 380 linearly spaced sample points in a 100 MHZ sweep are required.
8. When a test result is closer to the test limit than the accuracy of the field tester, the result shall be marked with an asterisk (*). Provide documentation to interpret results marked by an asterisk.
9. The Link test shall include all patch cables and line cords.
10. Any reconfiguration of link components after testing may change the performance of the link and thus invalidate the previous test result. These links shall be re-tested.
11. In general, provide certification that all cabling and equipment installed has been tested for wire mapping, cable length, NEXT, PS-NEXT, attenuation, ELFEXT, PS-ELFEXT, Return Loss, Prop. Delay and Delay Skew, shorts, opens, polarity, split pairs and that the pin configuration is consistent throughout the entire systems. (Category 5E backbone testing shall include testing for Powersum.)

H. Cable Television Wiring
1. All cabling shall be concealed within partitions or above ceilings. Install cabling in conduit from device box to space above closest accessible ceiling. Install cabling in conduit where located above gypsum board ceilings. Terminate cable in Tel/Data Room 019 on terminal blocks
2. Cable routes shall be with 90 degree angles whenever possible. Cables shall not be installed randomly or diagonally through the building.
3. Do not make splices of television cables.
4. Bundle cables above Lower Level ceiling with cable J-hooks. Do not install more than 14 cables per cable bundle. Separate cable bundles by 2” or more.

I. Test for Continuity and Short Circuits.

J. Fiber Optic Cable Testing: Test all fiber optic cable segments end-to-end from the Fiber optic

backbone patch panel in the main cross-connect to each Fiber optic backbone patch panel in each telecommunications closet.

3.19 CLEANING UP

A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.

B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.

C. Repair damage to finish surfaces resulting from work under this Section.

D. Remove material and equipment from areas of work and storage areas.

E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.

F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

END OF SECTION