# SECTION 16700: COMMUNICATIONS STANDARDS

**(NOTE: This Guide Specification incorporates the University's criteria for communications cabling. This Section is to be used for development of communication specifications for Contract Documents. The Design Professional shall be responsible for assuring the specifications are compatible with the overall design, and are coordinated with all other sections.)**

## PART 0.00 DESIGN GUIDELINES

### 0.01 GOALS

A. Data service at standard speeds up to and including 1 Gb/s (IEEE 802.3z standard) for copper cabling.

B. Voice over IP (VoIP) service capability within five years.

C. Station cabling media types and density to support all communications service for 10+ years. This implies media support for, at minimum, 10 Gb/s full duplex data service on fiber cabling.

D. Network equipment closet space to allow simultaneous support for two generations of data service and support parallel voice services from existing and VoIP systems.

E. Network equipment closets to support all communications services for 25 years.

### 0.02 DEFINITIONS

1. Cable

Horizontal Cable:

Communication cable installed between a Communication Room and a Communication Plate. Cabling is typically 4-pair copper and/or duplex fiber optic cable.

Intra-Building Backbone Cable:

Communication cable installed between Communication Rooms located in the same building. Cabling is 25-pair or greater copper and/or multiple strand fiber optic cable.

Inter-Building Backbone Cable

Communication cable installed between Communication Rooms located in different buildings. Cabling is 25-pair or greater copper and/or multiple strand hybrid fiber optic cable.

2. Communication Room Designations

- ADF (Area Distribution Frame):
- MDF (Main Distribution Frame):

- BDF (Building Distribution Frame):
- IDF (Intermediate Distribution Frame):

3. Hardware

1. Communication Plate

0.03 CABLE AND CONNECTORS

A. Intra-Building Cable

1. General

a. Plenum, CMP rated cabling is required in all "exit rated" hallways and plenum type air handling ceilings. Refer to NEC for further requirements. All other cabling shall be CMR rated

2. Horizontal Cable

a. All horizontal cable shall have both its ends terminated on the same floor.

b. Horizontal copper cable shall be Category 5e and shall not exceed an end-to–end distance of 90 meters.

c. Horizontal fiber optic cable shall be 2-strand 62.5 micron multi-mode.

3. Backbone Cable

a. Both a copper and a fiber optic backbone cable shall be installed between a building's BDF and each IDF within a building.

b. Backbone copper cabling shall be Category 3.

c. Backbone copper cabling will be sized to 0.55 x plate count-closet (PC-C) and rounded up to the next full 25-pin binder group. PC-C is the plate count terminated in the closet served by the backbone cable.

d. Backbone fiber optic cable. Cable shall be on tight tube construction.

e. Backbone fiber optic cabling shall be a 3:1 ratio of 62.5 micron multi-mode (MM) to 9 micron singlemode (SM) strands.

f. Backbone fiber optic cable and shall have a minimum strand count of 18MM/6SM.

1. Inter-Building Cable

a. Backbone copper cable shall be a Category 3 rated, flooded, shielded and of PE jacketed construction.

b. Backbone copper cabling will be sized to 0.55 x plate count-building (PC-B) and rounded up to the next full 25-pin binder group. PC-B is the plate count terminated of the building served by the backbone cable. An additional binder group (25 pair) shall

also be included in all copper backbone cabling for campus control and alarms. A minimum 50 pair cable shall be used.

c. Backbone fiber optic cable shall be of tight tube construction with an inner jacket OFNR, and an outer non metallic rodent resistant PE jacket.

d. Backbone fiber optic cable shall be a 2:1 ratio of 62.5 micron multi-mode (MM) to 9 micron singlemode (SM) strands.

e. Backbone fiber optic runs from an ADF (or MDF) to a BDF shall have the minimum strand counts:
   1. Large Buildings – 60 strands 36MM/24SM
   2. Small Buildings & Resident Halls – 36 strands 24MM/12SM
   3. Trailers – 12 strands 8MM/4SM

f. All backbone fiber optic cable shall be run in innerduct.

2. Cable Connectors

a. All horizontal cable connectors must fit into a standard keystone faceplate opening.

b. Horizontal copper cable shall be terminated on RJ45 connector wired to T568B standard.

c. Horizontal fiber optic cable shall be terminated with MT-RJ type connectors.

d. Backbone fiber optic cable shall be terminated with a simplex type “SC” connector.

## 0.04 COMMUNICATION PLATES

A. Communication Plate Types

1. Table 1 below lists the types and quantities of cables that will be in the wall plate for the various room types.

2. Room types not shown on this list will be evaluated on a case by case basis.

TABLE 1

| PLATE TYPE | Cables to Wall Plate | |
|---|---|---|
| | COPPER CAT5e | DUPLEX FIBER |
| Singular | 1 | 0 |
| Base | 2 | 0 |
| Standard | 2 | 1 |
| Standard Plus | 2 | 2 |
| Expanded | 3 | 1 |
| Cluster 8 | 8 | 0 |

B. Density and Location of Communication Plates by Room Type

1. General

a. Wall plates shall be located on the walls at a height of 38” to center line.

b. Telephone Wall Plates are generally located at a height of 46” to center line.

c. Wireless Plate locations may be located on a wall or ceiling; the specific location should be assessed on a case by case basis.

2. Office and General Space:

| OFFICE | |
|---|---|
| Square Footage | Quantity & Type of Plate |
| Less than 120 sf<br>120 to 200 sf<br>200 to 300 sf<br>Greater than 300 sf | 2 Standard Plates on opposite walls.<br>3 Standard Plates.<br>4 Standard Plates.<br>4+ Standard Plates - One plate per 100 sf, with a minimum of 4 plates. |

*(Note, assessment of square footage shall include aisles and common space.)*

3. Classrooms & Lecture Halls:

- *1 classroom plate on each wall*
- *1 campus phone plate at doorway*
- *1 wireless plate mounted at ceiling height*

Should additional classroom network services be required in the future, space for network terminations and electronics are to be created through an in-room data cabinet.

4. Computer Teaching Labs:

*Text Required*

5. Non–Computer Teaching Labs:

- *1 Non-computer teaching lab plate on each wall*
- *1 campus phone plate at doorway*
- *1 wireless plate mounted at ceiling height*
- *Labs with adjacent service rooms, two duplex fiber jacks and one CAT5e cable to use for local servers and in-room networking.*

*Should additional teaching lab network services be required, space for network terminations and electronics are to be created through an in-room data cabinet.*

6. Instructional Computing Labs:

1 instructional computing plate per each linear 6 ft of wall

- *1 campus phone plate at doorway*
- *1 wireless plate mounted at ceiling height*

7. Research Labs:

a. Less than 120 sf 2 research lab plates, and
1 ceiling jack for wireless
b. 120 to 300 sf 3 research lab plates, and
1 ceiling jack for wireless
c. 301 to 600 sf 4 research lab plates, and
2 ceiling jacks for wireless
d. 601 to 1200 sf 5 research lab plates, and
3 ceiling jacks for wireless

1. In all labs, install one campus phone plate at doorway.

8. Server Rooms:

Size closet on assumption of one data jack per 5 sf. Jack clusters to be mounted on server equipment rack with cable tray to wall. Provide 12 strands of fiber, 4sm/8mm, per rack fed from the nearest backbone closet.

9. Doorway – Campus Phone:

*Text Required*

10. Wireless Access Points:

One wireless access point plate per 25 occupants in public areas (Add Sq. ft requirements)
Utilize accessible corridor cable tray locations whenever possible

11. Library - Public Access Areas:

*Text Required*

12. Public Areas – Lobbies, Lounges:

Two plate locations, each with two CAT5e cables installed.

13. Interior Interactive Spaces:

Minimum of one interior interactive spaces plate per interactive space.

14. Trailers:

One Trailer plate per every 60 sf.

## 0.05 WIRELESS SYSTEMS

*The power for the wireless hub will utilize 1 pair of the installed CAT5e cable.*

## 0.06 PHYSICAL INFRASTRUCTURE

A. General

1. The standard wiring topology for all new buildings, and for new wiring and network implementations in existing buildings, is direct, dedicated, radial wiring between the BDF (or IDF) and the communication plate.

2. All horizontal cable shall be terminated in equipment racks.

3. All intra-building copper backbone cable shall be terminated on 110 style tower systems.

4. All intra-building fiber optic cable shall be terminated in equipment racks.

5. All inter-building copper backbone cable shall be terminated on 110 style tower systems, with the exception of the cable end inside an ADF. Within an ADF, copper backbone cable shall terminated on fully loaded 110 style protection blocks.

6. All inter-building fiber optic cable shall terminate in equipment racks with the except of cable

7. Unused or abandoned cabling and associated hardware shall be removed.

8. Pathway Fill

    a. Allow for growth and change during the pathway life cycle (25 years) with a minimum 60% spare capacity when initially installed.

    b. Both conduit and cable tray systems shall be designed to a maximum 40% fill.

    c. Design cable tray static loading at 80% of total capacity.

    d. Conduit

    1. The size of a homerun conduit from a single communication outlet shall be no less than 1.0”.

    2. The size of a homerun conduit from the base communication outlet of a daisy chained run shall be no less than 1.25”. The size of the conduit between the base outlet and the next outlet shall be no less than 1.0”.

    3. A daisy chain run shall never have more than 2 communication outlets.

0.07 Communication Rooms

## PART 1.00 GENERAL

A. Work shall consist of the provision, installation, labeling, testing, and documentation of a complete and fully functional telephone and data communications cabling system(s). Typical work shall include, but is not limited to providing and installing:

1. Horizontal and backbone cables.
2. Termination frames, racks and patch panels.
3. Faceplates and connectors.
4. Equipment racks and cabinets.
5. Complete support, suspension, attachment, fastening, bracing and restraint of the work according to standard engineering practices.
6. All incidental items as required for complete and fully functional system(s).

7. Work shall not include either provision or installation of the following:

   a. Patch cords.
   b. Telephone handsets (except for outdoor campus phones and/or emergency phones.)
   c. Telephone switching equipment.
   d. Telephone services.
   e. Active computer and networking equipment.
   f. Computer and network software.

B. RELATED WORK
**(Consultant to select & coordinate appropriate sections.)**

a. Section 02XXX – Procedures for Working with Asbestos Containing Wall Board

b. Section 07XXX – Firestopping.

c. Section 16XXX – Electrical General Requirements

d. Section 16XXX – Basic Electrical Materials and Methods Standards

e. Section 16XXX - Underground Distribution

f. Section 16XXX- Conduit

g. Section 16XXX - Raceway and Cable Tray

h. Section 16XXX - Grounding and Bonding

C. QUALITY ASSURANCE
**(Consultant to coordinate with Division 1)**

The Contractor has successful experience in 3 similar installations within the last 3 years. Submitted documentation shall include a description of experience, contact person(s) familiar with the work, and telephone numbers.

For projects of over 10,000 gross square feet or with estimated communication construction cost greater than $20,000 the Contractor shall retain a BICSI RCDD (Registered Communications Distribution Designer) to oversee the work. The RCDD shall have sufficient experience to perform technical support during installation. The Contractor shall submit RCDD certification for the 16700 communication specialist.

D. SUBMITTALS

1. Materials

The Contractor shall, submit six (6) copies of complete manufacture's product data sheets for each component of the telephone and data systems. All product data sheets shall be bound within a three-ring loose-leaf binder and organized in the same manner as the Materials section of these specifications. When more than one product is listed on the same page of a submitted product data sheet, the intended products or part numbers shall be clearly indicated.

The Contractor shall submit a list of all test equipment to be used for all cable testing.

The Contractor shall submit all proposed test procedures along with a sample printout of the test result form(s).

For all fiber optic cable submitted, the Contractor shall also submit:

The manufacturer's rating for maximum cable tension and minimum cable bend radius during installation.

The manufacturer's scheme for identifying individual fibers (i.e. color code).

The test documentation of the Contractors pre-installation test of backbone fiber optic cable.

2. Shop Drawings

The Contractor shall submit scaled drawing elevations (showing dimensions, mounting locations and associated frames & equipment) for all required assemblies, including but not limited to:

Telephone termination boards.
Wall mounted copper cable terminations.
Wall mounted fiber optic cable terminations.
Copper cable patch panels.
Fiber optic cable patch panels.
Rack layouts.

3. Samples

a. The Contractor shall submit a mock up sample of each type of communication outlet including conduit, wall box, faceplate, communication cables, jacks and jack identifying labels.

b. The Contractor shall submit a sample of each type of label to be used for labeling cables, patch panels, termination frames, and faceplates for the telephone and data systems.

4. REFERENCE STANDARDS

The cable system shall meet the standards set forth in the American National Standards Institute / Electric Industries Association / Telecommunications Industry Association recommended standards and manufacturer's requirements, particularly the following standards:

a. ANSI/EIA/TIA-568-A, ANSI/EIA/TIA-568-A-5, ANSI/EIA/TIA-568-B -- Commercial Building Telecommunications Cabling.

b. ANSI/EIA/TIA-568-A-1 - Propagation Delay and Delay Skew Specifications for 100 ohm 4-pair Cable.

c. ANSI/EIA/TIA-568-A-2 - Commercial Building Standards Updates

d. ANSI/EIA/TIA-569A-1998 - Telecommunications Pathways and Spaces.

e. ANSI/EIA/TIA-606 -- The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

f. ANSI/EIA/TIA-607 -- Commercial Building Grounding and Bonding Requirements for Telecommunications.

g. ANSI/EIA/TIA TSB-67 -- Transmission Performance Specifications for Field-Testing of Unshielded Twisted-Pair Cabling Systems.

h. ANSI/EIA/TIA TSB-75 -- Additional Horizontal Cabling Practices for Open Offices.

## PART 2.00 PRODUCTS

A. General

a. All materials and equipment provided must be new products of manufacturers regularly engaged in the production of such products.

b. All materials must be UL listed where a UL test procedure is applicable.

c. All materials must be ANSI/EIA/TIA listed where an ANSI/EIA/TIA test procedure is applicable.

d. Telephone system materials and equipment shall be FCC Type-accepted and certified as such by supplier.

B. COPPER CABLES & ASSOCIATED HARDWARE

a. Horizontal Cable - Non-Plenum

CMR rated interior distribution cable, 4 pair 24 AWG solid copper conductors, twisted pair, unshielded, PVC jacketed cable. Cabling shall be warranted by the manufacturer to provide ANSI/EIA/TIA Enhanced Category 5 (Cat 5e) performance when installed in accordance with applicable ANSI/EIA/TIA standards, and when terminated with jacks supplied by the Contractor. Cable shall be YELLOW in color.

Belden, General Cable, Berk-Tek or equal.

b. Horizontal Copper Cable - Plenum

CMP rated interior distribution cable, 4 pair 24 AWG solid copper conductors, twisted pair, unshielded, FEP insulated & jacketed cable. Cabling shall be warranted by the manufacturer to provide ANSI/EIA/TIA Enhanced Category 5 (Cat 5e) performance when installed in accordance with applicable ANSI/EIA/TIA standards, and when terminated with jacks supplied by the Contractor. Cable shall be YELLOW in color.

Belden, General Cable, Berk-Tek or equal.

c. Pigtail / Intra-building Backbone Copper Cable - Non-Plenum

CMR rated interior backbone cable shall be multiple pair (25 to 600 pair counts,) 24 AWG, solid copper, PVC jacketed cable with an overlapped, corrugated aluminum shield. Cable must meet ANSI/EIA/TIA Category level 3 specifications.

Belden, General Cable, Berk-Tek or equal.

d. Pigtail / Intra-building Backbone Copper Cable - Plenum

CMP rated interior Backbone cable shall be multiple pair (25 to 600 pair count,) 24 AWG, solid copper, FEP insulated & jacketed cable. Cable must meet ANSI/EIA/TIA Category level 3 specifications.

Belden, General Cable, Berk-Tek or equal.

e. RJ21 Pre-Connectorized Copper Cables

CMR rated interior 24 AWG, solid copper, PVC jacketed cable pre-connectorized with one MALE and one FEMALE 50-pin RJ21 connectors Cable must meet ANSI/EIA/TIA Category level 3 specifications.

Belden, General Cable, Berk-Tek or equal.

f. Inter-building and Under Slab Backbone Copper Cable

Cable shall be 24 AWG, flooded, solid copper, corrugated aluminum shield, black polyethylene jacket, and color-coded to telephone industry standard. Cable shall be CALPETH REA PE 89 and conform to ANSI/EIA/TIA ICEA 7CFR-1755-890. Cable pair counts within the sheath shall be exactly as noted on plans.

Alcatel, Essex, Avaya or equal.

g. Copper Cable Ground Clamps

1. For cables of small diameter: 3M Scotchlok P/N: 4460-S Shield Bond Connector (with shoe) or equal.

2. For cables of large diameter: 3M Scotchlok P/N: 4462 Shield Bond Connector or equal.

h. COPPER CABLE CONNECTORS & TERMINATION HARDWARE

1. Horizontal Copper Cable Connector

   Construction: Jacks shall be 8 position un-keyed. Each jack shall be an individually constructed unit and shall snap mount in an industry standard (.760" x 580") keystone opening. Jacks shall be in conformance with ANSI/EIA/TIA 568A

2. Jacks shall have a designation indicating C5e+ on the nose, which can be plainly seen from the front of the faceplate. Jacks shall terminate 22-26 AWG solid conductors. Jacks shall be marked with a T568B wiring schemes in separate locations.

3. Performance and certification requirements: CSA Certified File # LR80837, UL Listed 1863, UL verified for ANSI/TIA/EIA category 5e electrical performance.

4. Hubbell Speedgain Xcelerator Category 5e jacks P/N: HXJ5EOR (Orange) or equal, no known equal.

i. Horizontal Copper Cable Patch Panels – Rack Mount

1. Panel shall be 19" EIA rack mountable unloaded patch panel made of 16-ga. steel. Panels shall be 24 ports per rack unit (RU) and shall be no more than 2 RUs in height. Ports shall be sized to flush mount snap in keystone jack modules. There shall be port identifier label space on the front. Panel shall be installed with a management bar at the rear.

   Hubbell P/N UDX48E, Siemon, Panduit or equal.

2. Rear cable management bar shall have integral stain relief ties and fasten to back of unload patch panel.

   Hubbell P/N PCBLMGT, Siemon, Panduit or equal.

j. Underground & Premise Copper Backbone Splice Case Enclosures

1. Underground Cases: Splice case shall be capable of re-entry, watertight, pressurized enclosures, capable of either straight inline or butt splices option and sized as appropriate (but no larger than necessary unless otherwise noted) for the entering cables.

   3M, K&B, PSI or equal.

2. Premise Cases: Splice cases are to provide a transition point from unlisted, gel-filled outside plant cable to interior grade cable. Case shall not be pressurized nor encapsulated. Cases shall be of fire-retardant plastic construction and shall be capable of re-entry.

   3M, Uraseal, K&B or equal.

k. Splice Connectors – Copper

Splice connectors shall be 25 pair splicing modules featuring an array of U-shaped, phosphor bronze contacts. Modules shall be gel-filled with a water-blocking compound. Splice connectors shall be installed using the vendor's recommended splicing tool - no substitutions to vendors recommended splicing tool shall be allowed. **(Design Consultant to confirm type of splice module to be used.)**

Straight thru splice modules: 3M P/N: MS2 4000-C/TR series splicing modules, 3M 710 series or equal.

Half-tap splice modules:4008-C/TR series , 3M 710 or equal.

l. Backbone Copper Cable Termination Blocks – Protected

Underground telephone cables terminating at LIM locations shall utilize surge protected punch blocks. Provide the # of plugs equal to 100% of the number of cable pairs terminated.

1. Protection Blocks (Design Consultant to confirm type of protection block to be used.)

66 type, 100 pair Protection Blocks: Reliance/Com Tec P/N: FO19601 or equal, no known equal.

110 type, 100-pair Protection Blocks: Avaya P/N: 188B1-100, or equal.

2. Protection Modules

Modules shall be of solid-state design and provide over -voltage and sneak current protection.

Avaya P/N: 4C1S modules. Reliance/Com Tec or equal.

m. Backbone Copper Cable Termination Blocks – Non-Protected, 110 Tower System

Termination Blocks: Insulation displacements connector blocks consisting of oxygen free mechanical fastening system arranged in a flame-retardant molded plastic fastened to a mounting bracket. Features/Functions: "110 type" punch down type with color coded 5-pair connecting blocks with cable routing space behind the blocks. Shall conform with REA PE-87. Complies with Avaya Communication 110 Premise Distribution System Specifications.

Misc. Hardware: Standoff tower mounting brackets, horizontal cable managers between each 110 block, cable manager trough at the bottom of each column of blocks, vertical cable managers on each side of each column(s) of blocks. Grounding kit. 110 labels and label holders.

System shall be size as required. All connecting parts for 110 blocks shall be made by the same manufacturer.

Siemon S110 Modular Tower System to include:

| | |
|---|---|
| Tower Termination Kit: | P/N: S110MA2-***FT |
| Large Vertical Cable Manager | P/N: S188-*** |
| Small Vertical Cable Manager | P/N: S110M-WM-*** |

Base Horizontal Cable Manager P/N: S188-WD
Grounding Kit P/N: S188-GND

(*** = pair capacity)

**(Design Consultant to confirm size of vertical cable manager to be used.)**

Ortronics 110-PBS Modular System, Hubbell or equal.

n. Pre-Wired 110 to RJ-21 Copper Termination Blocks – Wall Mount

(Blocks to be mounted on a full 110 tower system as described in the product specifications for non-protected backbone termination blocks above. Pigtails shall reach top of tower.)

110 Type 100 pair leg-less terminal block with pre-wired FEMALE RJ21C connector on end of pigtail stub cable. Assembly shall meets Category 3. Connecting blocks shall be for 4 pair.

Siemon S110AB-100CT** (** = length in ft), Panduit or equal.

o. Pre-Wired RJ-21 to RJ45 Copper Patch Panel – Rack Mount

Rack mounted 19" EIA patch panel. Front Face: T568B RJ-45. Rear Face: Pre-wired MALE RJ-21C connectors (50 Pin). Printed circuit board linking RJ-45's to RJ-21C with all four RJ-45 pairs wired straight through. Meets Category 3. At least 24 Jacks per rack unit (RU).

Hubbell 25 Pair Telco Patch Panels P/N BRMCC2580419 or equal, Avaya, Ortronics equal.

p. Backbone and Horizontal Copper Cable Termination Blocks - Outdoor Cabinets

(Blocks to be mounted on a full 110 tower system as described in the product specifications for non-protected backbone termination blocks above. Tower system to use small vertical cable managers.)

q. Backbone and Horizontal Voice Cable Termination Blocks

Category 5e leg-less 110 Blocks 100-pair termination block: Siemon P/N: S110DW2-100, Ortronics, Hubbell or equal.

r. Horizontal Data Cable Termination Patch Blocks

Termination blocks shall be a 12 port Category 5e 110 Modular Patch blocks. RJ45 jacks shall be configured to T568B wiring and shall be mounted on the outside rows of the 110 block. The 110 block shall be leg-less. Connector blocks shall be color-coded 4 pair type.

Siemon P/N: S110AB5-100JPA, or equal, no known equal.

C. FIBER OPTIC CABLE & INNERDUCT

1. Horizontal Fiber Optic Cable

Horizontal fiber optic cables (multimode) must meet the following standards: ANSI/EIA/TIA 568, ANSI/EIA/TIA 598-A, ANSI/EIA/TIA 758, ANSI X3T9.5 PMD, ICEA-83-596, Gr-409-CORE, ATM 155 Mb/s, FDDI 100 Mb/s, Fiber Channel FC-PH.

Multimode: Fiber strands in all cables shall have a core diameter of 62.5 +/- 3 microns and a cladding diameter of 125 +/- 2 microns, exclusive of protective buffer coatings. Fibers shall be graded index glass with a numerical aperture of 0.275 +/ - 0.02. Attenuation loss shall be less than 3.0 dB/Km and modal bandwidth shall be 200 MHz-Km or greater, both when measured at 850 nm; and less than 1.0 dB/Km and modal bandwidth shall be 500 MHz-Km or greater, both when measured at 1300 nm. Fiber strands are coated with a mechanically strippable dual layered UV curved acrylate.

Horizontal fiber optic Cable shall contain 900-micron tight buffered multimode fibers surrounded by Aramid strength members and a flame retardant out jacket no greater than 0.20" in diameter. For UL-listed type OFNR, cable standards will be in accordance with NEC sections 770-51 (b) and 770-53 (b) and for UL-listed type OFNP, cable standards will be in accordance with NEC sections 770-51 (a) and 770-53 (a).

Strand count for Horizontal Fiber Optic Cable shall be 2 multimode fibers U.O.N.

Horizontal Fiber Optic Cable shall have a non-plenum jacket U.O.N.

Product: 2-strand, OCC DX-Series Micro Assembly Cables, or equal, no known equal.

2. Backbone Fiber Optic Cable

Backbone fiber optic cables (single mode and multimode) must meet the following standards: ANSI/EIA/TIA 568, ANSI/EIA/TIA 598-A, ANSI/EIA/TIA 758, ANSI X3T9.5 PMD, ICEA-83-596, Gr-409-CORE, ATM 155 Mb/s, FDDI 100 Mb/s, Fiber Channel FC-PH.

Multimode: Fiber strands in all cables shall have a core diameter of 62.5 +/- 3 microns and a cladding diameter of 125 +/- 2 microns, exclusive of protective buffer coatings. Fibers shall be graded index glass with a numerical aperture of 0.275 +/ - 0.02. Attenuation loss shall be less than 3.0 dB/Km and modal bandwidth shall be 200 MHz-Km or greater, both when measured at 850 nm; and less than 1.0 dB/Km and modal bandwidth shall be 500 MHz-Km or greater, both when measured at 1300 nm. Fiber strands are coated with a mechanically strippable dual layered UV curved acrylate.

Singlemode: Fiber shall have a mode field diameter of 9.3 +/ - 0.5 microns@1310nm, a cladding diameter of 125 +/- 21 microns, and a coating diameter of 245 +/- 10 microns. Attenuation loss shall be less than 0.4 dB/Km when measured at 1300 nm, and less than 0.3 dB/Km when measured at 1550 nm Fiber strands are coated with a mechanically strippable dual layered UV cured acrylate.

Backbone fiber optic cables shall be tight buffer, NEC OFNR rated, rated for installation in an underground duct. Cables shall have a crush resistance of 1,800 N/cm, an impact resistance of 1,500 impacts, a flex resistance of 2,000 cycles and a ripcord inside the outer jacket. For UL-listed type OFNR, cable standards will be in accordance with NEC sections 770-51 (b) and 770-53 (b) and for UL-listed type OFNP, cable standards will be in accordance with NEC sections 770-51 (a) and 770-53 (a).

Outside Plant backbone fiber optic cables shall be rodent resistant armor utilizing an all-dielectric fiberglass yarn encompassing the OFNR jacket of the cable. This armor shall be covered by a polyethylene overjacket.

Strand count and mode of fiber for Backbone fiber optic cable shall be as indicated on the Plans. Strand count shall not be greater than as indicated on Plans.

Outside Plant Backbone Fiber Optic Cable - Optical Cable Corp. Ultrafox DX rodent resistant series, or equal, no known equal.

Premise Backbone Fiber Optic Cable - Optical Cable Corp. Ultrafox DX series, or equal, no known equal.

3. Fiber Optic Innerduct
(Design Consultant to confirm type and size of innerduct to be used.)

   a. Outside plant innerduct shall be 1.0" I.D., smooth outer wall/ribbed inner wall, orange in color, sequentially marked footage with factory installed pull rope. (Note, Outside plant innerduct shall be transitioned to Premise innerduct prior to entry into building.)

      Carlon P/N AF2B1A- *** (***= length in ft.), or equal.

   b. Premise innerduct shall be 1.0" I.D., corrugated, orange in color, and have sequentially marked footage with factory installed pull tape. Innerduct shall be CMP rated.

      Carlon P/N CF4X1C- *** (***= length in ft.), or equal.

   c. Coupling, plugs, adapters specifically design for use with innerduct shall be used wherever appropriate.

   d. Products shall be approved for use by the innerduct manufacturer.

4. FIBER OPTIC CONNECTORS & TERMINATION HARDWARE

   Fiber Optic Connectors

      a. Horizontal fiber optic cable connectors shall be of type MT-RJ, typical insertion loss of .30 dB and max loss of 0.75 dB.

         Hubbell P/N: FCMTRJ62, Corning or equal.

   b. Backbone fiber optic connectors shall be of type SC, with ceramic ferrules, typical insertion loss of 0.30 dB and max loss of 0.75 dB. Connector shall be beige for multimode, blue for singlemode

      Corning, 3M, Avaya, or equal.

5. Horizontal Fiber Optic Cable Distribution Panels - Rack Mount

   a. Panel: 2RU Rack Mount distribution panel capable of housing 48 cables.

Hubbell P/N: FCR350SP36, Corning, or equal.

b. Connector Panels (Quantity shall be for port count as indicated on the plans.) 12-position MT-RJ connectors panels.

Hubbell P/N: FSPMTRJ6, Corning, or equal.

6. Backbone Fiber Optic Cable Distribution Panels - Rack Mount

a. Panel: 5RU Rack Mount distribution panel capable of housing 12 6-position simplex SC connector panels.

Corning P/N: FDC-CMH-072. To match existing or equal, no known equal.

b. Connector Panels (Quantity shall be for port count as indicated on the plans.), utilizing 6-position SC simplex connector panels.

Corning P/N: FDC-CP1P-38 (SM) or 39 (MM). or equal, no known equal.

7. Backbone Fiber Optic Cable Distribution Cabinet - Inside Wall Mount

a. Cabinet: Wall-mounted aluminum panel with a 48-fiber capacity. Panel shall meet NEMA 12 and IEC IP52 requirements. Cabinet shall feature an inner door for the left-hand compartment that can be secured with KS-style security screw. Outer door shall have hasp for accepting a University supplied padlock. Cabinet shall have a 'clamshell' clamp for securing backbone cable. Outer door and all entry holes shall be gasketed.

Corning P/N FBT-048 or equal, no known equal.

b. Connector Panels (Quantity shall be for port count as indicated on the plans.), utilizing 6-position SC simplex connector panels.

Corning P/N LDC-CP1P-38 (SM) or 39 (MM) or equal, no known equal.

8. Backbone Fiber Optic Cable Distribution Cabinets - Outside Wall Mount

a. Panel: Wall-mounted composite construction panel with a cabinet capacity for 12, 36 or 72 fibers depending on cabinet size. Panel shall meet NEMA 4X and IP66 requirements. Cabinet shall have a hinged gasketed outer door that shall be secured with both screws and a quick release latch that will accept a University supplied padlock.

Corning P/Ns:
EDC-02P-NH (12-fiber capacity) or equal, no known equal.
EDC-06P-NH (36-fiber capacity) or equal, no known equal.
EDC-12P-NH (72-fiber capacity) or equal, no known equal.

9. Connector Panels (Quantity shall be for port count as indicated on the plans.), utilizing 6-position SC simplex connector panels.

Corning P/N CCH-CP06-38 (SM) or 39 (MM) or equal, no known equal.

D. COPPER and FIBER OPTIC CABLE COMMUNICATIONS OUTLET HARDWARE

1. Wall Mounted Horizontal Cable Faceplate – Copper only

   Provide complete telecommunications outlet assembly, including but not limited to: Faceplate with industry standard keystone openings, Blank connector modules installed in faceplate openings not filled with connector modules, Labels and label holders.

   Requirements/Features: Single gang, Openings for up to 4 keystone jack connector modules, use 45 degree sloped “angled” jack connector modules, ANSI/EIA/TIA 606 labeling capability. Color shall be Office White.

   a. Faceplate: Hubbell Infin-e-Station Plate Frames or equal, no known equal.

   b. Jack Module: Hubbell Infin-e-Station Unloaded Modules P/N: IM2KA15OW or equal, no known equal.

   c. Blank Module: Hubbell P/N: SFB10 or equal, no known equal.

2. Wall Mount Horizontal Cable Faceplate - Copper & Fiber Optic

   Multimedia/ telecommunications outlet assembly, including but not limited to Faceplate with industry standard keystone openings, blank connector modules in faceplate openings not filled with connector modules, and labels and label holders.

   Outlet base shall have mounting holes that will allow mounting over a standard single or double gang wall box. Outlet cover shall have an ANSI/EIA/TIA 606 standard compliant label area. Dimensions: 5.5”W x 6.5”H x 1.25”D; Color shall be Office White.

   Requirements/Features: Must be compatible with UTP, STP, Coax, and Fiber cables. Outlets shall accommodate MTRJ and duplex SC optical fiber adapters. Outlet base shall have an integral cable storage areas that maintain minimum bend radius for optical fiber and allow the storage of at least 1 m of slack for up to 6 installed fibers. Outlets shall be capable of accommodating up to 6 fiber and 4 copper cables simultaneously. Outlets shall be located on the side and bottom when the outlet is mounted to a vertical surface. Port locations on the sides shall be angled 45 degrees downward to help maintain patch cord bend radii.

   Fiber optic MTRJ adapter modules shall snap in faceplate. Adapter shall be Keystone feed-through, flush mount in design. Color shall be yellow.

   Faceplate: Hubbell OFPPL Multimedia Plate P/N: OFPPL or equal, no known equal.

   MTRJ Module: Hubbell P/N: FAMTJKY, or equal, no known equal.

   Blank Module: Hubbell P/N: SFB10 or equal, no known equal.

3. Surface Raceway Mount Horizontal Cable Faceplate – Copper and/or Fiber Optic

Provide complete telecommunications outlet assembly, including but not limited to: Faceplate with industry standard keystone openings, Blank connector modules installed in faceplate openings not filled with connector modules, Labels and label holders.

Requirements/Features: Single gang, Openings for up to 4 keystone jack connector modules, use 45 degree sloped "angled" jack connector modules, ANSI/EIA/TIA 606 labeling capability. Color shall be Office White.

4. 1" fiber optic cable storage spacer ring shall be used when Horizontal fiber optic cable is installed. Color shall be White

   a. Faceplate: Hubbell Infin-e-Station Plate Frames or equal, no known equal.

   b. Jack Module: Hubbell Infin-e-Station Unloaded Modules P/N: IM2KA15OW or equal, no known equal.

   c. MTRJ Module: Hubbell P/N: FAMTJKY, or equal, no known equal.

   d. FO Ring: Siemon, P/N: CT4-RING-100(02) or equal, no known equal.

   e. Blank Module: Hubbell P/N: SFB10 or equal, no known equal.

5. Floor Box Horizontal Cable Mounting Frame - Copper & Fiber Optic

   A106 frame 4 port to provide snap-in module access within a rectangular (GFCI) or duplex electrical design. Color shall be Office White.

   a. 106 Frame: Hubbell P/N: Q106O, Siemon, Panduit or equal.

   b. MTRJ Module: Hubbell P/N: FAMTJKY, or equal, no known equal.

6. Stand Alone Wall Mount Telephone Horizontal Cable Faceplate

   Stainless steel faceplate with provisions for installing a wall-mounted telephone set flush to the wall surface. Plate shall opening that accepts the keystones jacks modules specified by this project

   Hubbell 630 Wall Phone Plates P/N: P630S1G, Siemon, Panduit or equal.

E. EQUIPMENT RACKS & ASSOCIATED HARDWARE

1. Equipment Rack – Floor Mount

   Rack: 7' x 19" x 6" clear finish aluminum equipment rack with universal 5/8"-5/8"-1/2" alternating hole pattern

   CPI Deluxe CatRack, or equal, no known equal.

2. Equipment Racks – Wall Mount

   Size as indicated on Plans. **(Design Consultant to confirm type and size of innerduct to be used.)**

12 RU (21") height – Zero PFT P/N: SO2118M or equal.
20 RU (35") height – Zero PFT P/N: SO3518M or equal.
25 RU (44") height – Zero PFT P/N: SO4318M or equal.

3. Floor Mount Rack Cable Management - Double Sided Vertical

   a. 3.65"W for end of rack rows or for single standing racks: CPI P/N: 12096-503, or equal, no known equal.

   b. 6.0"W for between racks: CPI P/N: 12729-503, or equal, no known equal.

4. Floor or Wall Mount Rack Cable Management - Single Sided Horizontal

   2RU horizontal duct finger cable manager, front only.

   Panduit P/N: WMPF1, Hubbell, or equal.

5. Wall Mount Cable Management - Cable Guide Rings

   2" metal 'D'-ring: Allentel P/N: GB13A, CPI, or equal.
   3" metal 'D' ring: Allentel P/N: GB13B, CPI, or equal.
   5" metal 'D' ring: Allentel P/N: GB13C, CPI, or equal.

F. OUTSIDE TELEPHONES

1. Blue Light Telephone

   Telephones shall be line-powered speakerphones specifically designed to work with a 1A2 key telephone system ring down circuit. Telephone shall be hands free, operable by one button only on stainless steel faceplate. Telephone must immediately establish two way talk path with dispatcher upon connection, not send any DTMF or any other messaging on connection, and must automatically hang up after use without user or dispatcher action. Telephone must be UL listed, comply with FCC part 68 rules, include a puncture and moisture resistant speaker, and be secured via tamperproof security mounting screws utilizing a 1/8 hex (Allen) key.

   Telephone shall be CEECO model P/N: 'WPP-531-X-R-w/Braille Plate', To match existing, no substitutions.

2. Outside Campus Phone

   Telephone shall be hands free touch-tone speakerphone mounted on stainless steel faceplate. Telephone enclosure shall have a spring-loaded door. Telephone must be UL listed, comply with FCC part 68 rules, include a puncture and moisture resistant speaker, and be secured via tamperproof security mounting screws utilizing a 1/8 hex (Allen) key.

   Telephone shall be CEECO model P/N: 'WPP-531-F-SP', To match existing, no substitutions."

G. MISC..

1. Duct seal: Plastic permagum duct seal.

Anixter P/N: 009386, Blackthorn, or equal.

2. Spiral Wrap: clear 0.125-inch nylon spiral wrap.

   Corning, Avaya or equal,

3. Pullrope

   Pullrope shall be 3/8" nylon having not less than 200lb tensile strength.

4. Hook/Loop Cable Ties:

   Panduit (HCL or HTL series as applicable), Velcro or equal.

## PART 3.00 EXECUTION

A. General

1. All work shall be performed in such a manner that the convenience of the general public shall be interfered with as little as possible.

2. The University's Representative shall provide plans for the communications room(s) indicating the locations of all racks, cable trays, patch panels, fiber termination cabinets, cable management systems, termination blocks, any other additional equipment and all cable routing pathways. These locations shall be indicated along with all clearances and measurements necessary for placement of all equipment and hardware in the closet. **(Design Consultant to confirm.)**

3. Contractor shall not use existing cables or splice cases for support of equipment or personnel.

4. All system cabling and terminations shall be installed in accordance with the manufacturer's instructions.

B. Cable Installation

1. Apply a chemically inert lubricant to all cable prior to pulling in conduit.

2. Do not subject cable to tension greater than that allowed by the manufacturer. For underground fiber optic cable, use pulling equipment with tension gauges to verify that cable pulls do not exceed allowable pulling tension.

3. Use multi-spool rollers where cable is to be pulled in place around bends. The maximum pulling angle may not exceed 90 degrees.

4. Verify that all conduit, cable tray and/or raceway has been de-burred and properly joined, coupled, terminated, and grounded prior to installation of cables. Verify that all conduit, cable tray and/or raceway is clear of foreign matter and substances prior to installation of cable.

5. Cable loops and bends shall not have a radius less than that recommended by the manufacturer.

6. All shielded cables shall be insulated and grounded. Do not permit shields to contact conduit, raceway, boxes, panels or equipment enclosures.

7. All underground fiber optic backbone cable shall be installed in innerduct unless specified otherwise. Underground rated innerduct shall be transitioned to rated innerduct in the last manhole or vault before entering the building.

8. Vendor recommended couplers are to be used whenever connecting to pieces of innerduct

9. All inter-building ducts, including conduit entries, are to be plugged with duct seal after cables have been installed.

C. Splices

1. All horizontal cable shall be continuous and splice free for the entire length of the run between designated connections or terminations unless otherwise specified.

2. All backbone cables, both copper and fiber optic, shall be continuous and splice free except for transition splicing of backbone copper cable in communication rooms at ends of the cable or where specifically shown on the construction drawings.

3. All specified splice cases shall be sealed as per the manufacturer's instructions.

4. All underground splice cases shall be pressure tested. The Contractor shall notify the University's Representative 48 hours in advance of the test(s).

5. All splice cases shall be securely mounted with University approved brackets to the sides of vaults or backboards, unless otherwise specified.

D. Routing

1. Horizontal cable runs shall not exceed 90 meters (295 feet). Report to the University's Representative any conditions causing this requirement to be exceeded before cable installation begins.

2. All cable shall run loose throughout all pathways. Cable shall not be secured with plastic cable ties, electrical tape or similar binding except in the cable closet. Hook & Loop cable ties shall be the only binding allowed in the cable closet.

3. Access to access-doors, hatches, air dampers, valves, cable trays, junction boxes, pull boxes, conduit entries or similar areas of access shall not be obstructed.

Where drawings specifically allow the installation of cable in void, plenum, suspended ceiling areas or under trailers, the contractor shall conform to ANSI/EIA/TIA 569, 10.4 with respect to separation from power and radio frequency (RF) sources per table 10.4-1. Provide at least the listed separation distance at fluorescent light fixtures, ballast and similar high intensity electromagnetic field sources, including but not limited to motors and transformers.

E. Support

1. Where drawings specifically allow the installation of cable in void, plenum, suspended ceiling areas or under trailers, the contractor shall provide support for all cable. Do not place or attach cable directly to t-bar grid, concealed spline grid, flexible or rigid ductwork, HVAC registers, sprinkler piping or fixtures, light fixtures or building structure.

2. Support all cables in a neat and workmanlike manner, neatly training all cables in exposed areas (e.g. vaults, backboards and cable trays.)

3. All cable support hardware must be a minimum of 1-inch wide with rounded edges to maintain proper cable bend radius.

4. Cable supports shall be no further than 60" on center. Cable shall not sag more than 12" between supports.

5. One or two-hole type conduit clamps are not allowed for use as cable guides. When guiding cable on backboards, 'D' rings of the appropriate size are to be used.

6. Secure all cable runs vertically for continuous distances greater than ten (10) feet. Provide symmetrical conforming non-metallic bushings or woven cable grips appropriate to weight of cable(s).

F. COPPER CABLE TERMINATION

1. General

   a. At each end of a horizontal cable run, the outer jacket shall be stripped no more than is necessary for the proper termination of the cable as called for by the manufacturer of the hardware to which the cable is being attached.

   b. When terminating a cable, the integrity of the twist for each individual pair shall be maintained up to the point of termination.

2. Termination of Horizontal Copper Cable at Communication Outlet

   a. Unless otherwise noted on the plans, all communications outlets are to be installed at a height of 38" A.F.F. to centerline, with the exception of telephone wall jacks that shall be installed at height of 42" A.F.F. to centerline.

   b. All communications outlets shall be installed so that their edges are parallel to the vertical and horizontal edges of the surface on which they are mounted.

   c. Provide sufficient cable at the communications outlet to facilitate removal and inspection of the back of the terminated jack(s). Proper bend radius shall be maintained when cable is coiled in outlet boxes.

   d. All data and voice horizontal cable shall be terminated at the individual jack modules in accordance with ANSI/EIA/TIA T568B cabling configuration.

3. Termination of Horizontal Copper Cable in Rack

a. All horizontal cables shall be trained neatly inside the rear vertical cable managers. Cables shall not be braided together, but shall lie parallel to each other from the point where they enter the top of the vertical cable managers until they are terminated at the back of the patch panel. Cables terminating on the right or left side of the patch panel shall be routed via the right or left cable manager. Cables shall not cross the horizontal mid-point of the patch panel.

b. Cables terminated in a patch panel shall be neatly routed from the vertical cable manager to the patch panel. Hook & loop ties shall be used to organize the cables into groups of 12 cables as they exit the cable manager.

c. When terminating in pre-existing 110-style patch panels, cables shall be terminated starting with either the green or orange pair and working outwards towards the blue and brown pairs. Cable jackets shall be cut back as little as possible at the termination point.

d. For patch panels designed for snap-in connectors, follow the manufacturer's instruction for strain relief.

e. All horizontal cables shall be terminated in ascending order according to their identifying number.

f. All horizontal cables shall be separately terminated on a 48-position T568B Category 5E rack-mounted patch panel. Terminate the cables in numerical order, lowest to highest beginning in the upper left position (port#1) of the patch panel working left to right, top to bottom.

4. Termination of Voice RJ21 Interconnect Tower and Panel

a. Overview: The RJ-45 patch panel with RJ-21 connectors, in combination with the 'RJ-21 Interconnect Tower and connecting cables, is used to supply voice service (dial tone) to the equipment rack. Each RJ-45 port on the patch panel represents four pair of connection to the RJ-21 interconnect tower. Service is routed to the rack via 25-pair cables connectorized with RJ-21 connectors.

b. If specified on the plans, backbone cables shall be terminated to 110-blocks in the upper section of the 110 tower system. RJ-21 connectorized 110-blocks shall be placed in the lower section of the 110 tower system**. (Design Consultant to confirm positioning of backbone cable.)**

c. The 25-pair cables used to connect the RJ-45/RJ-21 patch panel with the 110/RJ-21 110 tower shall be routed from the patch panel to the rear vertical cable managers, across the ladder rack and terminate to the RJ-21 connectorized 110-blocks pigtails. The first connectorized 110-block on the tower system shall be connected to the first connectorized patch panel port, and each subsequent 110-block shall be connected in order to the next higher numbered patch panel port. RJ-21 Male and Female connectors shall be fastened together with either hook & loop straps or retaining screws.

d. The RJ-45/RJ-21 patch panels shall be placed below the last horizontal cable patch panel in the data rack and separated from that panel with a horizontal cable manager.

e. Termination of Backbone Copper Cable

All underground copper backbone cables terminating in a communications room containing telephone electronics shall be terminated on fully loaded protector blocks. At all other locations underground cables are to be terminated on wall mounted 110 tower blocks.

All pairs and binder groups are to be terminated according to the Bell color code industry standard.

All underground cable shall be grounded at each point of termination.

All underground cable, containing more than 25 pairs, shall be transition spliced to a shielded PVC CMR cable. (Grounding of underground cable shall be continuos through transition cable.)

All backbone cable shall be routed around the outer edge of the backboard.

5. Termination of Horizontal & Backbone Copper Cable in NEMA Cabinet

a. 110 tower shall be installed with small-scale vertical managers on both the left and the right sides of the tower.

b. Backbone voice cables shall be terminated to the uppermost 110-block(s) using C5 connector blocks.

c. Horizontal voice cables shall be terminated to the next lower 110-block(s) using C4 connector.

d. Horizontal data cables shall be terminated to Category 5e 110 Patch Block(s) placed in the lowest position(s) of the tower.

All connections shall be machine labeled using clear label holders. The insert labels and holders shall not interfere with running, tracing or removing patch cords. Label holders must be capable of mounting between each row of connecting blocks.

Horizontal cable organizers supplied with the tower system shall be used between all 110-blocks and above the top 110-block.

A ground bar shall be installed on each Tower system. Each tower shall be grounded in accordance with ANSI/TIA/EIA 607(A) - Commercial Building Grounding and Bonding Requirements for Telecommunications, National Electrical Code, ANSI/NECA/BICSI-568 and manufacturer's grounding requirements as minimum.

G. COPPER CABLE TESTING – HORIZONTAL CABLE

1. General

a. Contractor is responsible for supplying all of the required test equipment used to conduct acceptance tests.

b. Contractor is responsible for submitting acceptance documentation as defined below in the Test Report Documentation subsection of these specifications.

c. Test reports shall be submitted within seven (7) business days of completion of testing.

2. Test Equipment

a. Test equipment used under this contract shall be from manufacturers that have a minimum of 5 years experience in producing field test equipment. Manufacturers must be ISO 9001 certified.

b. All test tools of a given type shall be from the same manufacturer, and have compatible electronic results output.

c. All test adapter cables must be approved by the manufacturer of the test equipment. Adapters from other sources are not acceptable.

d. Baseline accuracy of the test equipment must exceed ANSI/EIA/TIA TSB67 Level III specified instrument accuracy, as indicated by independent laboratory testing.

e. Test equipment must have a dynamic range of at least 100 dB to minimize measurement uncertainty.

f. Test equipment must be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.

g. Test equipment must include S-Band time domain diagnostics for NEXT and return loss (TDNXT and TDRL) for accurate and efficient troubleshooting.

h. Test equipment must be capable of running individual NEXT, return loss, etc measurements in addition to auto-tests. Individual tests increase productivity when diagnosing faults.

i. Test equipment must include a library of cable types, sorted by major manufacturer.

j. Test equipment must store auto-tests in internal memory.

k. Test equipment must be able to internally group auto-tests and cables in project folders.

l. Test equipment must include DSP technology for support of advanced measurements.

m. Test equipment must make swept frequency measurements in compliance with ANSI/EIA/TIA 567 standards.

n. The measurement reference plane of the test equipment shall start immediately at the output of the test equipment interface connector. There shall not be a time domain dead zone of any distance that excludes any part of the link from the measurement.

3. Test Process

    a. Testing shall be of the Basic Link. The Contractor shall warrant performance based on Channel performance and provide patch cords that meet channel performance. Testing shall only be performed after the cabling plant is completed, and all faceplates, jacks, patch-panels, and all other components are in their final location.

    b. All pairs of all of the installed cabling must be tested. All tests must pass acceptance criteria defined in these specifications.

    c. Any installed horizontal cable cabling requiring repair or replacement shall be re-tested at no additional cost to the University.

    d. All cabling not tested strictly in accordance with these procedures shall be re-tested, and any cabling requiring repair or replacement shall be re-tested at no additional cost to the University.

    e. Test equipment shall be fully charged prior to each day's testing

4. Test Report Documentation – General Requirements

    a. Test reports shall be submitted in both hardcopy and electronic format. Hand-written test reports are not acceptable.

    b. For installations of more than twenty (20) cables, the Contractor shall submit electronic reports with hardcopy summaries are preferred. Hardcopy summary reports shall contain the following information on each row of the report: circuit ID, test specification used, length, date of test, and pass/fail result.

    c. Electronic reports are to be submitted on 3.5 inch diskettes or CD format. If proprietary software is used, disk or CD shall contain any necessary software required to view test results. If the results are delivered in a standard format like Excel, Access, CSV files, etc. then software to read these files need not be provided.

    d. A Certificate signed by the Contractor shall accompany submitted Test Reports. The Certificate shall warrant the truth and accuracy of the electronic report, and include the manufacturer's model and serial number of the test equipment, the date of the test, and the name(s) of the contractor and/or personnel responsible for the testing. Certificate must reference traceable circuit numbers that match the electronic record.

    e. Hardcopy reports are to be submitted in labeled binders with an attached Certificate.

    f. Test reports shall include the manufacturer model and serial number of the test equipment, date of the test, and name(s) of the contractor and/or personnel responsible for the testing.

5. Test Report Documentation Requirements

Test reports shall include the following information for each cabling element tested:

a. Wiremap results that indicate the cabling has no shorts, opens, miss-wires, split, reversed, or crossed pairs, and end to end connectivity is achieved.

b. For Category 5e: Attenuation, NEXT, PSNEXT, Return Loss, ELFEXT, and PSELFEXT data that indicate the worst case result, the frequency at which it occurs, the limit at that point, and the margin. These tests shall be performed in a swept frequency manner from 1 MHz to highest relevant frequency, using a swept frequency interval that is compliant with ANSI/EIA/TIA requirements for Category 5e cabling. Information shall be provided for all pairs or pair combinations and in both directions when required by the appropriate standards. Any individual test that fails the relevant performance specification shall be marked as FAIL.

c. Length (in meters), propagation delay, and delay skew. Any individual value that fails the relevant performance specification shall be marked as FAIL.

d. Cable manufacturer, cable model number/type, and NVP.

e. Tester manufacturer, model, serial number, hardware version, and software version.

f. Circuit ID number and project name

g. Auto-test specification used.

h. Overall pass/fail

i. Date of test.

H. COPPER CABLE TESTING – BACKBONE CABLE

a. A new cable shall be tested only after all wires within the cable have been terminated at both ends. Measurements are to be made by applying meter probes and shorting connections directly to the terminating punch block knives.

b. For unshielded cable, "measurements to ground" means an electrical connection to building steel, electrical metallic conduit or a water pipe.

c. The Contractor shall supply the University's Representative with printed documentation of all test results. Test data shall be supplied to the University in both hard copy (paper) and electronic (computer disk) formats. If specialized software is required to read the report, the contractor shall supply the necessary software.

d. If the maximum number of defective pairs that are not repairable exceeds 4% of the cable's pair count, the cable shall be deemed unacceptable and must be replaced. Replacement and re-termination of new cable shall be at no additional cost to the University.

g. Tests to be performed:

TEST #1 - Continuity:

1. Meter set for ohm reading. Each pair shall be shorted at one end and the loop resistance value read at the other.

2. The difference between the largest and the smallest resistance reading from each pair in the cable shall be no more than 10 percent of the largest reading.

3. All resistance readings are to be recorded.

TEST #2 - Balance, Polarity and Conductor Transpositions:

1. Upon passing Test #1, the tester at one end of cable shall ground tip side of each pair in turn. The tester at other end of cable reads resistance to building ground of same conductor.

2. REQUIREMENT: Reading for each tip conductor in pair of approximately one-half the loop resistance value from Test #1.

3. All resistance readings are to be recorded.

I. FIBER OPTIC CABLE TERMINATION

General

1. The Contractor shall review the termination procedure with the University's Representative prior to beginning this phase of the work.

2. All glass debris shall be collected and disposed of in a manner approved by the University's Representative.

a. Termination of Horizontal Fiber Optic Cable at Communications Outlet

1. Provide sufficient fiber optic cable at the communications outlet to facilitate removal and inspection of the back of the terminated connectors and for re-termination of fiber connectors, if necessary. Proper bend radius shall be maintained when cable is coiled in outlet boxes.

b. Termination of Backbone & Horizontal Fiber Optic Cable in the Communications Room

1. Backbone Fiber Optic cable shall have service loops of 15 - 25 feet of cable. Mount the fiber loop to the backboard unless otherwise directed by the University's Representative. Do not store cable slacks in bundled loops. Store the cable slack in an extended loop or in a figure 8 configuration to alleviate stress.

2. Horizontal Fiber Optic cable shall be dressed in the distribution wall or rack panel as per the manufacturer's recommendations

3. Display both connectorized and non-connectorized fibers entering each patch panel.

4. Strip back a sufficient amount of cable such that the fiber strands wrap at least one full wrap, circle or figure eight, inside the panel with the connectorized ends attached to the most distant bulkhead connectors.

5. For Backbone Fiber Cable, group together the fibers from each binder group with 0.125 inch nylon spiral wrap.

J. FIBER OPTIC CABLE TESTING

1. General

a. After final installation and labeling, the Contractor shall perform fiber optic cable testing on all installed fiber optic cabling. The Contractor shall notify University's Representative in writing at least 48 hours in advance that fiber testing shall commence.

b. The Contractor shall supply the University's Representative with printed documentation of all test results. Test data shall be supplied to the University in both hard copy (paper) and electronic (computer disk) formats. If specialized software is required to read the report, the contractor shall supply the necessary software.

c. For inter and intra-building cables, test each fiber strand in every cable in both directions for link loss attenuation utilizing the specified test equipment. Horizontal fiber strands shall be tested for link loss attenuation in one direction.

d. OTDR (Optical Time Domain Reflectometer) testing shall not be used as a substitute for power-meter light loss testing.

e. OTDR testing shall be performed as a part of material pre-acceptance test and on all cables that are spliced.

f. Attenuation testing shall only be performed after all fibers have been terminated and dressed in the distribution panels/cabinets.

2. Standards Compliance & Test Requirements

The maximum allowable attenuation for both horizontal and backbone fiber Optic cable and connectors shall be:

| | |
|---|---|
| Multimode fiber measured at 850 nm | 3.5 dB/Km |
| Multimode fiber measured at 1300 nm | 1.5 dB/Km |
| Singlemode fiber measured at 1310 nm | 1.0 dB/Km |
| Singlemode fiber measured at 1550 nm | 0.5 dB/Km |
| Connector | 0.75 dB |
| Mechanical splice | 0.30 dB |
| Fusion splice | 0.30 dB |

3. Pre-Installation Acceptance Test

a. Perform a pre-installation attenuation acceptance test on all strands of all fiber cables while on the factory reels. Measure the attenuation per kilometer at 850 nm for multimode and at 1300 nm for single mode using an Optical Time Domain Reflectometer (OTDR). The refractive index setting of the OTDR shall be set to the value specified by cable manufacturer. The OTDR shall be calibrated and certified within thirty days prior to the test.

b. Upon measuring the strand attenuation and verifying that the length of all strands matches the cable length, the Contractor shall document their findings and furnish to the University's representative accompanied by a copy of the above-mentioned calibration certificate.

c. If the attenuation test results do not meet the University's specifications then the Contractor shall notify the University's Representative in writing and obtain direction prior to installing the cable.

4. Power Meter Test

a. Power meter attenuation test shall be performed in accordance with the 1998 BICSI Telecommunications Distribution Methods Manual, chapter 12 which is derived from ANSI/EIA/TIA-524-14 "Method B: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant."

b. Test jumpers shall be made from fiber with the same core diameter as the link being tested. Test equipment shall be Noyes OPM5-2C optical power meter and Noyes OLS-1 dual wavelength optical light source, or equal.

5. OTDR Test

a. A narrow pulse OTDR capable of resolving features 10 meters apart shall be used (Corning model 340+ OTDR or equivalent).

b. OTDR testing shall be performed from both ends of spliced strands. Vertical scale factor shall be 1 dB per centimeter or less to show the fiber performance at the splice.

c. A launch cable of length sufficient to permit the reflections from the launch connector to be resolved shall be used to permit distance between injection and the splice to be measured on the OTDR.

6. Test Report Documentation

a. Both Power meter and OTDR Test results for each fiber strand in each direction shall include:
Date of test
Name of person testing
End-to-end cable length
Test wavelength
Cable designation and strand designation
Strand core diameter (Single or Multimode)
Testing direction (location of light source)
Brand, model and serial # of test equipment
A copy of the calibration certification

b. Power meter attenuation measurements shall also include:
The attenuation in dB for each strand
The value of P[ref], the launch power in dBm

c. OTDR Splice measurements shall also include:
Pulse width setting on the OTDR

Vertical (dB per division) scale factor
Horizontal (distance per division) scale factor
Printout or photograph that shows the step attenuation or reflection at the splice. A copy of the test results on disk (.SOR format) shall be supplied to the University.

K. LABELING

1. General

a. All labeling shall be per ANSI/EIA/TIA 606.

b. Prior to the installation of communications cabling work, the University's Representative shall provide the Contractor with one (1) marked plan set on which a unique identifier for every horizontal and backbone cable is clearly identified. It shall be the contractor's responsibility to label all installed work according to this master set.

c. Machine-generated labels are to be used for all labeling.

d. All labels shall be securely fastened.

2. Horizontal Copper & Fiber Optic Cable Labeling

a. The terminated ends of each cable shall be clearly labeled with its assigned identifier on both the communication plate and the patch panel or termination block.

b. For horizontal cables run to elevator mechanical rooms, the cable identifier shall be affixed to the cable itself, both where it appears in the room's junction box and 1 ft back from the end of the cable.

3. Backbone Copper & Fiber Optic Cable Labeling

a. Within every manhole/vault/pullbox and within 4 ft of the entrance into a building every backbone cable's assigned identifier shall be affixed to either the cable's outer jacket or to innerduct in which the cable is installed.

b. Within every communication room, every backbone cable shall its assigned identifier affixed to its outer jacket within 4 ft of its entrance into the room.

c. All backbone copper cable termination blocks shall be labeled with both the pair count of every $5^{th}$ pair and the cable's assigned identifier.

d. Except where installed in innerduct or conduit, all backbone fiber optic cable shall have affixed to the outer jacket, labels of a bright color that contain at least the legend "FIBER OPTIC CABLE." These labels must be affixed at separations no greater than 10 ft.

e. All backbone fiber optic cable distribution panels shall be labeled with both the pair count of every fiber pair and the cable's assigned identifier.

4. RJ21 Pre-terminated Cable Labeling

a. All RJ21 pre-terminated cables shall be labeled with the corresponding pair count on the 110 tower that it is connected to (e.g. 001-100, 101-200 etc.) This label is to be affixed to each end of each cable within 6" of the RJ21 connector.

b. All RJ21 pre-terminated copper cable termination blocks shall be labeled with the pair count of every $5^{th}$ pair.

L. DOCUMENTATION

1. Test Procedures and Results

a. Cable test results shall be submitted in hard copy and magnetic format (3.5" floppy disk, zip disk or CDROM) along with viewing software from the tester manufacturer. Hard copy to be bound within loose leaf binder and organized first by Building Number, then by ADF, BDF or MDF and finally by Horizontal Cable/Jack Number.

2. As-Built Drawings

a. Upon completion of the project, the Contractor shall deliver to the University final documentation of "As-Built " drawings. All drawings shall be submitted in both hard copy and in AutoCAD V14 format.

b. As-Built documentation of the project shall include:

1. As-built telecommunications floor plans of the facility with cable and outlet placement, equipment locations, raceway, and conduit installations clearly depicted.

2. As-built elevations of all termination fields describing cable and outlet location labeling scheme.

3. As-built logical riser diagram describing connectivity and cable sizes for both telecommunications and grounding cabling systems.

4. Cabling diagrams showing terminal identification for field-installed cabling.

END OF 16700 SECTION