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27 00 00 COMMUNICATIONS

27 01 00 Operation and Maintenance of Communications Systems

Part 1 – General

The Owner's Information Technology Services department (NAU ITS) is responsible for ensuring the implementation of a fully compliant and efficient communication infrastructure to meet its needs. These standards apply to all campus departments, Design Professionals, developers, and Contractors involved in campus construction. All work must adhere to Building Industry Consulting Services International (BICSI) recommended installation practices, standards, and codes as outlined below. Coordination with the assigned NAU Project Manager and NAU ITS is required before construction and wiring placement.

Quality Assurance

The following requirements must be met by the telecommunications contractor, whether that contractor is hired directly by Owner as the prime Contractor or hired by the Contractor as a subcontractor.

A. The telecommunications contractor shall have a Registered Communications Distribution Designer (RCDD) as a company employee for the company on project staff and shall be an approved Belden Certified Installer.
B. Low voltage contractors who wish to bid outside plant construction must possess a current BICSI OSP (outside plant) design credential.
C. The A/V contractor shall have on staff CTS and CTS-I certified employees employed onsite during the project installation duration
D. A copy of the certification documents of the firm and the installers must be submitted to NAU ITS for verification that certification requirements are met prior to receipt of bids.
E. All price quotes with the specified warranty solution submitted to Owner for approval shall have all the part numbers and documents pertaining to the specifications of the materials being used for the project being quoted along with as-builts pertaining to BDF/IDF layouts.
F. The telecommunications system shall be designed by a current RCDD holder (OSP certified designer required for all outside plant scopes).
G. The telecommunications system installer shall perform project management/installation with oversight by a BICSI certified RCDD/OSP weekly.
H. The telecommunications system installer shall have a certified BICSI Technician as the lead technician, always employed on staff and on-site

during project construction. The lead technician shall be OSHA 30 trained and verified.

I. All telecommunications installers/technicians shall be BICSI certified or enrolled in a State authorized apprenticeship program. New members added to the AV and telecommunications installation team must be approved by Owner (NAU ITS). All A/V CTS/ CTS-I installers and telecommunications installers shall be OSHA 10 trained. A copy of the current certifications of all members of the installation team shall be submitted with the quote.

J. A system warranty for 25 years covering all components, equipment and workmanship shall be submitted in writing with system documentation as part of the closeout process. Owner has pre-approved the following solutions to be in compliance with these standards: SureBit, ChannelMate.

K. Should the cabling system fail to perform its expected operation within the contractor warranty period due to inferior or faulty installation and/or workmanship, the contractor shall promptly make all required corrections without cost to Owner.

L. Telecommunications System shall be complete Belden SureBit/ChannelMate Solution System. No mixing of warranty solutions will be allowed in any building. Faulty materials shall be promptly corrected by the manufacturer at no cost to Owner.

M. A/V cabling shall be Creston Digital Media for Crestron systems.

N. Verify with Owner for intended warranty on a per job basis.

O. Fiber optics shall be Belden.

P. No portion of the telecommunications cabling contract may be subbed out to another entity unless prior approval is granted by NAU ITS.

Q. Removal of all abandoned cabling shall be included in all Telecommunications installations and upgrades.

R. Owner has pre-approved the following manufacturers to be in compliance with these standards: (Belden) A/V (Crestron).

Note: Substantial as-builts shall be included in the Contractor's quote and provided prior to Substantial Completion of project.

Prior to sign-off of the FS #15 at time of Substantial or Final completion and release of payments: Owner reserves the right to test and verify compliance of all fiber and copper cables installed under contract.

Codes and Standards Compliance

A. Reference Division 01 41 13 for applicable codes.

B. All materials and installation practices shall comply with the applicable sections of the following telecommunications industry standards and all applicable addendums:

1. ANSI/TIA/EIA-569-C.0-2009+A1:2010+A2:2012, Generic Telecommunications Cabling for Customer Premise Standard
2. ANSI/TIA/EIA-568-C.1-2009+A1:2012, Commercial Building Telecommunications Cabling Standard,
3. ANSI/TIA/EIA-568-C.2-2009+A1:2010, Balanced Twisted Pair Telecommunications Cabling and Components Standard
4. ANSI/TIA/EIA-568-C.3-2009+A1:2010, Optical Fiber Telecommunications Cabling Systems Standard
5. ANSI/TIA/EIA-568-C.3-2009+A1:2011, Optical Fiber Cabling and Components Standard
6. ANSI/TIA/EIA-568-B.2-1: Transmission Performance Specification for 4-Pair 100 Ω Category 6 Cabling (Standard).
7. ANSI/TIA/EIA-569-C-2012, Commercial Building Standards for Telecommunications Pathways and Spaces
8. ANSI/TIA/EIA-570-C-2012, Residential Telecommunications Infrastructure Standard
9. ANSI/TIA/EIA-606-B-2012, The Administration Standard for Commercial Telecommunications
10. ANSI/TIA/EIA-607-B-2013, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
11. NECA/BICSI 607-2011 or current revision, Standard for Bonding and Grounding Planning and Installation Methods for Commercial Buildings.
12. ANSI/TIA/EIA-758-B-2012, Customer Owned Outside Plant Telecommunications Infrastructure Standard
13. TIA/EIA-1005-A-2012 Telecommunications Infrastructure Standard for Industrial Premises
14. BICSI/NECA-607 Telecommunications Bonding and Grounding, Planning and Installation Methods for Commercial Buildings
15. TIA/EIA-942-A-2012 Telecommunications Infrastructure Standard for Data Centers
16. TIA-TSB-190, 2011 Guidelines on Shared Pathways and Shared Sheath
17. NFPA 780- Standard for Installation of Lightening Protection Systems, latest issue
18. Telecommunications designers/ Contractors and installers shall have read the above documents and must be familiar with the

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requirements that pertain to this installation. The documents may be obtained from:
IEEE-Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY, 10017-2394, 800-678-IEEE, fax: 732-981-9667, http://standards.ieee.org/

For any questions or further information on applicable cabling standards, designs, and layouts, please contact NAU ITS for clarification.

Part 2 – Products
N/A

Part 3 – Execution
Any design or installation that does not meet all applicable codes and standards shall be remediated by the Contractor at no charge to Owner.

27 01 10 Operation and Maintenance of Structured Cabling and Enclosures

The operation and maintenance of all structured cabling systems is the responsibility of NAU ITS and all changes or modification shall be coordinated with NAU ITS.

27 01 20 Operation and Maintenance of Voice / Data Communications

The operation and maintenance of all data communications are the responsibility of NAU ITS and all changes or modification shall be coordinated with NAU ITS.

27 05 00 Common Work Results for Communications

27 05 13 Communication Services

All voice and data communication services to be supplied by or coordinated with NAU ITS. This includes dial tone services, T1 services, DSL services, Network services.

27 05 13.43 Cable TV Services:
NAU does not actively support CATV services and recommends end users leverage streaming services rather than coaxial tv end points.

27 05 26 Grounding and Bonding for Communications Systems

A Telecommunications Main Grounding Bus bar (TMGB) connected to the electrical grounding system is required in all buildings. All communication equipment spaces

require a Telecommunication Grounding Bus bar (TGB). The TMBG shall connect to each TGB via a telecommunications bonding backbone (TBB), which shall be sized based on the provided table below. Additionally, TGBs shall have a connection to a secondary approved building ground i.e., building steel. All connections bonded within a BDF/IDF require a minimum of 6 AWG conductors. The backbone bonding conductor shall be, as a minimum, the same size as the largest TBB. All cable tray, equipment racks, and equipment cabinets shall be bonded to the TGB. All Telecommunication protectors and associated metallic cable sheaths to be grounded to the nearest TGB. All copper pairs are to be protected at building entrance facility via a building entrance terminal (BET) with gas tube type 350VDC protector modules.

Table 1 - TBB/BBC Conductor Size vs Length

TBB/BBC Linear Length m (ft)	Conductor Size (AWG)
Less than 4 (13)	6
4 - 6 (14 - 20)	4
6 - 8 (21 - 26)	3
8 - 10 (27 - 33)	2
10 - 13 (34 - 41)	1
13 - 16 (42 - 52)	1/0
16 - 20 (53 - 66)	2/0
20 - 26 (67 - 84)	3/0
26 - 32 (85 - 105)	4/0
32 - 38 (106 - 125)	250 kcmil
38 - 46 (126 - 150)	300 kcmil
46 - 53 (151 - 175)	350 kcmil
53 - 76 (176 - 250)	500 kcmil
76 - 91 (251 - 300)	600 kcmil
Greater than 91 (301)	750 kcmil

27 05 28 Pathways for Communications Systems

All communication cabling shall be routed in a designed and approved pathway system per ANSI/TIA/EIA-569-C, (Commercial Building Standard for Telecommunications Pathways and Spaces) and meet or exceed all National, State

and Local codes and standards. Pathways shall run parallel to the building design. The design shall be documented in floor plans and have built-in flexibility for tenant movement and expansion and be designed for maintenance and relocation of cables as easily as possible. All pathway sleeves shall be rigidly secured on both sides of the wall. ISP and OSP fiber optic cabling that is not in conduit shall be placed inside plastic inner-duct unless an armored cable is used for safety, identification, and protection of the fiber. Pathways shall not exceed 40% initial fill volume when installed. When necessary additional sleeves and pathways shall be installed to meet the standard to not exceed 40% initial fill volume. A free and clear pull-line with a minimum 200lb pull rating will be available for future use and will be left in all main bundles/pathways and conduits. All cables are to be bundled in the ceiling in bundles not exceeding twenty-four (24) cables and in all BDF's/ IDF's or TR's.

When cables enter the closets, they will be packed neatly (i.e., cigarette packing).

OSP pathways refer to Div. 33 80 00 for standards for pathways.

Fire Wall penetrations shall be installed in accordance with the current Division 21 specifications. NAU ITS has pre-approved the following manufacturers for prefabricated fire stop solutions to comply with these standards: 3M, Hilti and STI (Specified Technologies Inc.).

27 05 28.29 Hangers and Support for Communications Systems

All cable supports shall be located on maximum of 48" on center and attached to both sides and ends of cable tray. All cable tray systems shall be comprised of the manufacturer's recommended hardware for a complete system. All cable supports shall be rated for Fiber Optic, and category 6A structured cabling systems. In a ceiling distribution design, at least 3" clearance between ceiling tile and cable or the lowest point in the communications system's support/anchoring. All hangers and supports must be suspended from or attached to the structural ceiling or walls with hardware designed to support the tray's maximum load bearing. Only Velcro-type cable straps shall be used for dressing or securing Fiber Optics and category 6A Cabling. J-Hook or straps for the support system shall be installed no greater than 48" on center and in accordance with all BICSI Design standards and industry best practices.

27 05 28.33 Conduits and Back Boxes for Communication Systems

All conduits shall be rigid. Flexible conduit is not acceptable for any application. Design and installation of conduits shall be run in the most direct route possible with no more than two 90-degree bends and should not contain any electrical condulets

(LB's). Conduits should not be placed over or adjacent to boilers, incinerators, hot water lines, electrical converters/rectifiers/panels, or steam lines. Conduits 2" or smaller require a bend radius of 6 times the internal conduit diameter, more than 2" require 10 times the internal conduit diameter. All conduit ends should be reamed and fitted with an insulated bushing. Specify a minimum of two 1" conduits to each office type room on opposite walls and stubbed out to accessible location in the same room. All other rooms (labs, classrooms, etc.) require consultation with NAU ITS. Conduits to terminate in a 5"x5" double gang box. Equip all conduits with a pull cord that has a minimum test rating of 200 lb. All conduits dedicated to communication structured cabling system and shall not be shared with any other services. Underground conduits that contain telecommunications cables shall terminate with Conduit End Bells inside the BDF/IDF, vault or maintenance hole and sealed after, whether in use or not. Conduits seals shall be re-enterable. Type of seal shall be approved by Owner. No rigid foams permitted.

27 05 28.36 Cable Trays for Communications Systems

The type and design of cable tray distribution system shall be pre-approved by NAU ITS. Cable tray installation must be installed to meet NEC (National Electrical Code®) article-392 and all state and local codes. Cable tray shall be dedicated to telecommunication use only and not shared with electrical. A/V (Audio/ Video) and Security may reside in the same pathway as Telecommunications **ONLY** with prior approval through NAU ITS. Physical separation shall be required when multiple applications other than telecommunications reside in the same tray. Design should be such that all requirements for a maximum 40% initial fill volume and a certified Category 6A structured cabling system will be met (i.e., bend radius, clearances, and distances etc.). Minimum (2) supports per section of cable tray and attached to both sides shall be maintained throughout the entire system.

Cable tray to be sized so as not to exceed the allowable initial maximum fill volume of 40% for all services residing in the cable tray or support system. All metallic cable trays shall be grounded and clearly marked in accordance with ANSI/TIA/EIA-606-A and ANSI J-STD-607-B-2013.

27 05 28.39 Surface Raceways for Communications Systems

Surface raceway should only be considered as last resort and with prior coordination with Owner. Raceway design should be of a type that conforms to Category 6A certification for bend radius, interference, and separation. Raceway must be capable of accepting the specified warranty solution's wiring products including jacks and faceplates. If electrical power and telecommunications services are both running in the raceway separate compartments are required and must

comply with applicable electrical codes. If a metallic barrier is provided, it must be bonded to ground. Raceway shall be sized so as not to exceed 40% initial fill rating.

All raceways shall be secured to surfaces via anchors of the appropriate type for the wall being attached to. The color of the raceway shall match the wall being attached to.

27 05 28.40 Furniture Raceways and Pathways

All furniture pathways shall adhere to ANSI/TIA/EIA-569-C current standards. Maximum pathway fill shall be 40%. The minimum size pathway shall not force the cable into a bend radius less than 1" under condition of maximum fill. Any parallel pathway to electrical must have proper separation. All furniture pathways must be capable of accepting the approved warranty products brand termination hardware.

27 05 43 Underground Ducts and Raceways for Communication Systems

See Division 33 for site communications ducts and maintenance holes. Under floor ducts systems shall be dedicated space for telecommunication cables and not shared with any other utility. The guideline for planning duct capacity is 1 in^2 of cross section for each 100 ft^2 of useable floor space. Junction boxes shall be placed at a maximum of 60 ft to allow access for cable placement. All distribution ducts must be physically linked to a telecommunication room directly or through no more than one feeder duct. Ducts entering the telecommunications room must terminate in either a slot or elbow.

27 10 00 STRUCTURED CABLING

For Owner (NAU ITS) to maintain ease of available stock, maintenance and administration, Belden systems will be installed.

Complete Belden ChannelMate solution for the structured cabling system to conform to all TIA/EIA Telecommunications Building Wiring Standards, latest edition of BICSI Telecommunications Distribution Method Manual and are covered by the ChannelMate System Performance Warranty shall be installed. A Belden Certified Installer will perform the telecommunications and AV structured cabling tasks.

Belden ChannelMate System Solution Warranty shall be required for all work performed on campus.
Berk-Tek Leviton may be used as a substitution for Belden when unavailable.

Structured Cabling color codes:

Application	Color
Data/Voice	Yellow
Wireless	Yellow
Access Control	Yellow

Cooper B-Line Wire Management and Racking: (Black finish only unless otherwise specified)

19" Rack	SB556084XUFB
Vertical Management	SB86086D084FB (Used for the outside management in a multiple rack design) SB860810D084FB (Used in between racks in a multiple rack design)

(Vertical Management shall run the entire length of the rack)

(Doors, spools, and hinges for a complete solution shall be included)

Horizontal Management	SB87019S1FB and SB87019S2FB
Ladder Rack	SB13AL12FB and SB13AL18FB
Elevation Kits	SB227R6FB
Radius Drops	SB13ALDO12FB and SB13ALDO18FB
Blank Panels	Color matching unbranded blanks to be used in unoccupied RUs

(All hardware kits for connectivity and support shall be included for a complete install)

Category 6A cabling is the minimum category cable for all communication designs and plenum in type.

27 11 00 Communications Equipment Room Fittings

All buildings shall have at least one telecommunications room per floor (depending on building size, footprint, and design). The building design shall be such that no permanent link horizontal cable run exceeds 90 meters. The design should be such that telecommunications rooms are as close to the building's center as possible. Multiple story buildings shall stack the telecommunications rooms. At least two 4"-conduits from each room to the Building Distribution Frame (BDF) are required. The space shall be dedicated to telecommunications equipment and not shared with electrical or any other building system. Equipment not related to the support of telecommunications closet (e.g., piping, ductwork, etc.) shall not be installed in,

pass through, or enter the telecommunications room. The minimum size shall be 10'X12' with no ceiling. Wall finish shall be white in color. Lighting shall be a minimum of 500 lx measured 3ft. above finished floor. Room shall be environmentally controlled to maintain 72° F or lower 24/7. The flooring shall be static free, with no carpeting. Power requirements are based on individual building design and need approval of NAU ITS, but at least 2 120V quad convenience outlets are required. Each telecommunications room shall be equipped with a grounding bus bar connected to the building telecommunications main grounding bus bar (TMGB). All walls shall be covered with 3/4" fire rated A-C plywood painted with (2) coats of white fire-retardant paint on all (6) sides. Entrance door shall be minimum of 36" opening outward. The backbone and horizontal cable pathways shall terminate into the room. Room cable management shall consist of ladder racks above all wall mount frames and all equipment racks.

Required BDF/ IDF Layout

A drawing of the proposed network rack layout shall be shared with Owner (NAU ITS) for consultation before construction.

At least 4 feet of clearance is required in front of and behind each newly installed equipment rack. When cables enter the BDF/IDF, they will be packed neatly (e.g., cigarette packing).
A dedicated patch panel shall be installed for each of the following cable types: Copper backbone, Wireless access point, and Data/Voice/ Horizontal cabling).

27 11 13 Communications Entrance Protection

All copper entrance cables are to be terminated on a stub-in and stub-out building entrance terminal, (710 Splicing Only for Stubs in and out) or a comparable substitute pre-approved by NAU ITS. The Building Entrance Terminal (BET) requires protection by a gas tube type module, capable of handling surges higher than 300 volts, sneak currents and incorporates a positive temperature coefficient self-resetting current limiter as is UL497 listed.
Circa 1900-100K series Stub In/ Out 100 pair BETs with covers recommended**. Consult with NAU ITS for recommendations and approval of BETs.**

27 11 16 Communications Cabinets, Racks, Frames, zone boxes and Enclosures

All network and telecommunication equipment will be housed in 7' 19" Black equipment racks. Any other enclosure type requires pre-approval of NAU ITS. Equipment racks shall meet ANSI/EIA-310-D standard. All metallic communications cabinets, racks, frames, zone boxes and enclosures are secured and grounded per

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manufacturer's instructions and all applicable codes. Racks shall be positioned a minimum of 4' from any wall in front of or behind it and minimum of 1” from the side wire manager to the wall. Rack equipped with horizontal cable management above and below all patch panels. Vertical cable management is required on both sides of the rack and on all rack designs. Racks shall be equipped with rack mount 19" or 23” power strip 20A/120v with minimum of 8 NEMA5 -20R receptacles. Rack configuration requires pre-approval of Owner (NAU ITS).

27 11 19 Communications Termination Blocks and Patch Panels

All OSP twisted pair to be terminated on a stub-in and stub-out building entrance terminal with the stub-in and -out spliced with 710 modules. BET type must be pre-approved before installation.

All Category 3 OSP cabling shall be terminated on BETs with stub-in and stub-out tails then transitioned to or directly terminated on Rack Mount unpopulated patch panel on pins 4/5 for analog transmission. Category 6A cabling to terminate on the same category type patch panels. Any analog or dial tone services shall terminate on patch panels in the Telco closets. No 66 or 110 blocks will be authorized for installation.

27 11 23 Communications Cable Management and Ladder Rack

All cable management shall conform to industry standards and comply with the specified warranty solution for fiber optic and Category 6A systems. All active and passive rack mount equipment to be separated by horizontal cable management. Vertical cable management required in all rack designs. All unused rack units will be filled with a color matching 1U blank panel. Ladder rack required to all racks and for cable entrance into all telecommunication rooms (18” wide Ladder Rack in the BDF/ IDF’s). All Category 3 OSP cable termination fields require transitioning to Rack Mount patch panels terminating on the 4/5 pins for an analog communication cross connect field with horizontal management above and below.

27 11 26 Communications Rack Mounted Power Protection and Power Strips

Minimum of one horizontal power strip 20A/120V with 8 NEMA5-20R receptacles. The power cord length shall be a minimum 8’ with NEMA5-20R plugs. If a UPS (Uninterruptible Power Supply) is provided it shall be supported by lithium-ION batteries.

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27 13 00 Communications Backbone Cabling

See Division 33 82 00 for site communications distribution and outside plant requirements. All campus buildings will be fed via a media type consisting of either twisted pair copper and/or 8.3-micron OS2 single-mode fiber. The number of conductors to be determined by Owner (NAU ITS) per project. 20' service loops shall be placed in all vaults, maintenance holes and termination points. A minimum of 24 strands of SM OS2 is required to feed each building. All fiber optic and copper communications backbone cabling shall be labeled at every corner and at all spans greater than 100' throughout.

27 13 13 Communications Copper Backbone Cabling

27 13 13.01 Intra Building Copper Backbone

Analog building backbone cabling shall consist of Yellow Category 6A (4) pr cabling certified to Category 6A specification and be compliant for the intended building system running from the BDF to each IDF. All cables will be homerun and terminated at both ends on Rack Mount unpopulated patch panels.

27 13 13.02 Inter Building Copper Cable Backbone

Copper cable shall be PE 39 type and meet the following requirements:

- 24 AWG pair count determined by NAU/ITS per project.
- Cable shall meet the requirements of ANSI/CEA S-84-608.
- Buried service wire to conform to ANSI/CEA S-86-634.
- The transmission requirements of connecting hardware used in the OSP shall comply with the connecting hardware requirements of ANSI/TIA/EIA 568-A.

27 13 13.13 Communications Copper Cable Splicing

All splicing and splice enclosures to conform to TIA/EIA-758 and be of the watertight and re-enterable type unless otherwise approved by NAU ITS. All splicing shall be completed with 710 type multiple pair connectors only. No bridge-taps, and 25-pair binder groups shall not be split between termination points. All splices housed in a closure compatible with all materials used in the construction of cable, filling compounds, bonding and grounding devices, chemicals, and sealants that the closure would come in contact under normal conditions. Closure construction shall be reusable and re-enterable without factory refurbishment. All closures to be filled with filling compound. Replacement parts shall be readily available.

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27 13 13.14	Copper Cable Testing

All Category 3 OSP twisted pair cable and category cabling intended for analog backbone will be tested with complete wire map and 100 % pass rate for following:

- DC loop resistance
- Wire map
- Continuity to remote end
- Shorts between two or more conductors
- Crossed pairs
- Reversed pairs
- Split pairs
- Any other miss-wiring

Data/Voice and Wireless Category 6A twisted pair cables will be tested with a 100% pass rate to the cable categories applicable standard for the following in accordance with Amendment 10 of the TIA/EIA-568-B.2 document:

- Insertion Loss (IL)
- Near End Crosstalk (NEXT)
- Power Sum Near End Crosstalk (PSNEXT)
- Attenuation to Crosstalk Ratio (ACR)
- Power Sum Attenuation to crosstalk Ratio (PSACR)
- Far End Crosstalk (FEXT)
- Equal Level Far End Crosstalk (ELFEXT)
- Power Sum Equal Level Far End Crosstalk (PSELFEXT
- Return Loss (RL)
- Wire Map
- Propagation Delay
- Delay Skew
- Length

27 13 23 Communications Optical Fiber Backbone Cabling

The Fiber Optic cabling system shall be Belden.

Fiber- SM

Maximum fusion splice loss shall be no greater than .03db. A Germania-doped silica core surrounded by a concentric silica glass cladding shall comprise each optical fiber. The fiber shall be a matched clad design manufactured by the outside vapor deposition process (OVD). Each optical fiber refractive index profile shall be step index.

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Each fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²). The fiber shall be coated with a dual acrylate protective coating and in physical contact with the cladding surface. The single-mode fiber shall meet EIA/TIA-492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU-T G.652.C, "Characteristics of Single-Mode Optical Fiber Cable." Fiber shall have a mode field diameter of 9.20 ± 0.40 µm at 1310 nm and 10.40 ± 0.50 µm at 1550 nm. Fiber core-clad concentricity shall be = 0.5 µm. Fiber cladding diameter shall be 125.0 ± 0.7 µm. Fiber cladding non-circularity shall be = 0.7%. Fiber coating diameter shall be 245 ± 5 µm.

The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5°C on the original shipping reel. The cabled fiber attenuation for Loose Tube and Ribbon cable constructions shall be < 0.4 dB/km at 1310 nm and <0.3 dB/km at 1550 nm. For tight buffered constructions, the cabled fiber attenuation shall be <1.0 dB/km at 1310 nm and <0.75 dB/km at 1550 nm. The attenuation at the water peak (1383 nm) shall not exceed the 1310 nm attenuation value. The cabled fiber shall be capable of operating in the 1360 nm to 1480 nm water peak region.

The attenuation due to 100 turns of fiber around a 50 ± 2 mm diameter mandrel shall not exceed 0.05 dB at 1310 nm and 0.10 dB at 1550 nm. The attenuation due to 100 turns of fiber around a 75 ± 2 mm diameter mandrel shall not exceed 0.10 dB at 1625 nm. There shall be no point discontinuities greater than 0.10 dB at 1310 nm and 1550 nm.

The maximum dispersion shall be = 3.2 ps/(nm•km) from 1285 nm to 1330 nm and shall be =18 ps/(nm•km) at 1550 nm. The cabled fiber shall support Gigabit Ethernet (GbE) operation according to the 1000BASE-LX (1310 nm) specifications up to 5000 m in accordance with the GbE standard. The cabled fiber shall support laser-based 10 Gigabit Ethernet (10GbE) operation according to the 10GBASE-LX4 (1300 nm region), 10GBASE-L (1310 nm) and 10GBASE-E (1550 nm) specifications for distances of 10 km, 10 km, and 40 km, respectively.

The cabled optical fiber shall support industry-standard multi-gigabit fiber channel physical interface specifications.

27 13 23.01 Building Optical Fiber Cable Backbone

Single-Mode OS2 fiber optic backbone is required between the BDF and all IDF locations. All cables shall be homerun with no splices and installed in a 1" plenum or riser rated (depending on the application) suitable inner duct unless armored type is used. Strand count to be determined by Owner on a per project basis.

ISP Cable- MIC 2-24 fibers plenum

Cable shall be plenum-rated, all-dielectric, with two to twenty-four 900 ± 50 µm tight-buffered fibers. Owner has pre-approved the following product to be in compliance with these standards: TBII® Tight-Buffered Fiber shall be made of a PVC material and shall have a UV-cured acrylate coating (low-friction slip layer) between the acrylate coating of the optical fiber and the PVC buffer.

The fiber coating, low friction slip layer and PVC buffer shall be removable with commercially available stripping tools in a single pass for termination or splicing. The individual fibers shall be color-coded for identification. The optical fiber color coding shall be in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." Fibers shall be stranded together around jacketed or non-jacketed dielectric strength members via reverse oscillation and surrounded with dielectric strength members and a ripcord. Cables containing 12 to 24 fibers shall have a dual-layer stranded design. The cable jacket color shall be orange for cables containing all multimode fiber, except for cables containing 50/125 µm, 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. The cable jacket color shall be yellow for cables containing all single mode fiber. Cable shall have a storage temperature range of -40° to 70°C on the original shipping reel, installation temperature range of 0° to 60°C, and an operating temperature range of 0° to 70°C. Cable manufacturer shall be ISO 9001 registered.

ISP Cable- UMIC 24-144 fibers plenum

Cable shall be all-dielectric and contain 36 to 144 900 ± 50 µm tight-buffered fibers. TBII® Tight-Buffered Fiber shall be made of a PVC material and shall have a UV-cured acrylate coating (low friction slip layer) between the acrylate coating of the optical fiber and the PVC buffer. The fiber coating, low friction slip layer and PVC buffer shall be removable with commercially available stripping tools in a single pass for termination or splicing. The individual fibers shall be color-coded for identification. The optical fiber color coding shall be in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." Fibers shall be stranded via reverse oscillation with dielectric strength members and a ripcord in either 6-fiber or 12 fiber subunits. Cable with < 60 fibers shall contain 6-fiber subunits, otherwise cable shall contain 12-fiber subunits. Subunits shall be stranded together in a planetary configuration around a jacketed or bare glass reinforced plastic (GRP) dielectric central member. Cable shall contain a ripcord underneath outer cable jacket to facilitate jacket removal. Each subunit jacket shall be made of a PVC material and shall be identified with a unique number at periodic intervals. Subunit color containing multimode fiber shall be orange. Subunit color containing 50/125 µm, 850 nm laser optimized fiber shall be aqua. Subunit color containing single-mode fiber shall be yellow.

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A dual-layer subunit design shall be used for cables containing 108 to 144 fibers. The cable jacket color shall be orange for cables containing all multimode fiber, except for cables containing 50/125 µm, 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. The cable jacket color shall be yellow for cables containing all single mode fiber. Hybrid cables (containing more than one type of fiber) shall have an outer jacket with the color corresponding to the greatest percentage of total fibers within the cable, except for hybrid cables containing 50/125 µm, 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. Cable shall be listed OFNP/FT-6 and be fully compliant with ICEA S-83-596. Cable outer jacket shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet (e.g., “NAME BRAND CABLE - 01/00 – 72 SM– TB2 - OFNP (ETL) OFN FT6 (CSA) 0001 FEET”). The marking shall be in contrasting color to the cable jacket.

Cable shall have a storage temperature range of -40°C to +70°C, installation temperature range of 0°C to +60°C, and an operating temperature range of 0°C to +70°C. Cable manufacturer shall be ISO 9001 registered.

27 13 23.02 Inter Building Optical Fiber Cable

Fiber Optic cable shall meet following requirements**:**
Cable shall be all-dielectric, stranded loose-tube design with dry water blocking for outdoor duct and aerial installations in fiber counts from two to 288. Each fiber shall be distinguishable by means of color-coding in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding.” The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tubes shall be made from polypropylene. Each buffer tube shall contain a water swellable yarn for water blocking protection. The water-swellable yarn shall be non-nutritive to fungus, electrically non-conductive, and homogeneous. It shall also be free from dirt or foreign matter. This yarn will preclude the need for other water blocking material; the buffer tube shall be gel free. The optical fibers shall not require cleaning before placement into a splice tray or fan out kit. The buffer tube shall be manufactured to a standard 3.0 mm in size, regardless of fiber count, to reduce the number of required installation and termination tools. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA/EIA-598-B. Buffer tube colored stripes shall be inlaid in the tube by means of co extrusion when required. The nominal stripe width shall be 1 mm. Buffer tubes in a hybrid cable (cable containing more than one type of fiber) shall contain only one fiber type. Identification of fiber types in a hybrid cable shall correspond to fiber core diameter (or mode field diameter) from smallest to largest in accordance with TIA/EIA-598-B. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation

stranding process. Two polyester yarn binders shall be applied contra helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage. Water swellable yarn(s) shall be applied longitudinally along the central member during stranding. For dual-layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two-layer core. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water-swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. Cable shall be comprised of water-swellable yarns and/or tapes, dielectric strength members (as required), ripcord(s) and an MDPE jacket containing carbon black to provide ultraviolet light protection while inhibiting the growth of fungus. Cable jacket shall be marked with the manufacturer's name, month and year of manufacture, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code® (NESC®), fiber count, and fiber type. The actual length of the cable shall be within -0/+1% of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The marking's height shall be about 2.5 mm. Cable shall contain reverse oscillation lay (ROL) markings as needed. Cable shall have a storage temperature range of -40° to 70°C, an installation temperature range of -30 to 70°C, and an operating temperature range of -40° to 70°C. Cable shall have a short-term tensile rating of 2700 N. No fiber strain shall occur over the service life of the cable when subjected to a maximum, long-term tensile rating of 890 N. Cable shall meet the functional requirements of Rural Utilities Service (RUS) 7 CFR 1755.900 and be fully compliant with ICEA S-87-640. The manufacturer shall be ISO 9001 and TL 9000 registered.

27 13 23.13 Optical Fiber Splicing and Terminations and Testing

Rack mount Housings:

Housing shall be of the same specified warranty as the structured cabling provided. Housings shall be mountable in an EIA-310 compatible 465- or 592 mm rack. Housings shall be available in both 1U ,2U and 4U sizes. One EIA rack space or panel height (denoted as 1U) is 44.45 mm high. The unit shall meet all applicable design requirements listed in ANSI/TIA/EIA-568, ANSI/TIA/EIA-942, and the polymer compounds flammability requirements of UL 94 V-0. The manufacturer shall be ISO 9001 and TL 9000 registered. Housings shall be manufactured using 16-gauge aluminum or equivalent for structural integrity and shall be finished with a black powder coat for durability. All joints shall be welded and finished in a workman-like manner. Installation fasteners shall be included and shall match the housing color. The unit shall include a cable clamping mechanism to provide cable strain relief.

The front and rear doors shall be lockable when used with an optional key lock kit. The connector housing shall have a labeling scheme that complies with ANSI/TIA/EIA-606. The housing shall be available with factory-installed connectorized cable stubs in multiple cable and connector types. The housing shall be able to accommodate fusion splicing with additional hardware. The housing shall be 16 inches deep for extra cable routing.

All fiber optic terminations/splices shall be fusion spliced.

All fiber optic connectors shall comply with all ANSI/ TIA/ EIA standards

Connectors LC/UPC SM

Connector shall be compliant with industry standard ANSI/TIA/EIA-568-B.3. The connector shall comply with the TIA/EIA Fiber Optic Connector Inter-mate ability Standard (FOCIS) document, TIA/EIA-604-2. The connector installation shall not require epoxies, adhesives, or ovens. The connector shall be installable upon 900 µm buffered fiber in one minute or less and upon 2.9 mm jacketed cable in three minutes or less total time. The connector shall be installable upon single-mode optical fiber. Ferrule material shall be ceramic. The connector shall be consistently capable of insertion losses of 0.3 dB (typical) and shall be 0.75 dB (maximum) when installed in accordance with the manufacturer's recommended procedure and tested in accordance with FOTP-171. Connector reflectance shall be measured after manufacture to be less than or equal to -40/-55 dB ultra physical contact (UPC). The manufacturer shall be ISO 9001 and TL 9000 registered. The manufacturer shall have an in-depth knowledge, and more than 10 years of manufacturing history, of manufacturing and supporting connector technology that does not require epoxy or polishing in the field.

Splice cases:

The fiber spice enclosures shall be available in canister (butt) and in-line styles to fit most applications. All end-caps feature two express ports for uncut feeder cables.

Splice case shall be resistant to solvents, stress cracking and creep. The housing materials shall also be compatible with chemicals and other materials to which they might be exposed in normal applications. The optical fiber closure shall be capable of accepting any optical fiber cable commonly used in interoffice, outside plant and building entrance facilities. As an option, the ability to double the cable capacity of an installed canister splice closure by use of a kit shall be available. Such a conversion shall not disturb existing cables or splices.

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Encapsulation shall not be required to resist water penetration. The splice closure shall be re-enterable. The closure endcap shall be able to accept additional cables without removing the sheath retention or strength-member-clamping hardware on previously installed cables or disturbing existing splices. The optical fiber splice closure shall provide a clamping mechanism to prevent pistoning of the central member or strength members and to prevent cable sheath slip or pullout. The splice closure shall have appropriate hardware and installation procedures to facilitate the bonding and grounding of metal components in the closure and the armored cable sheath. The cable bonding hardware shall accommodate a copper conductor equal to or larger than 6 AWG.

Aerial splice closures shall have available the necessary hardware to attach and secure the closure to an aerial strand. The closure shall accommodate splice trays suitable for single- fiber, single fiber heat-shrink, mechanical or ribbon heat-shrink splices. The small splice closure shall accommodate up to 72 single- fiber splices or 144 ribbon fiber splices using 12-fiber ribbons. The medium-sized closure shall accommodate up to 288 single-fiber splices or 432 ribbon-fiber splices. The large closure shall accommodate up to 480 single-fiber splices or 864 ribbon-fiber splices. The installation of the splice closure shall not require specialized tools or equipment, other than those normally carried by installation crews.

All fibers (inter and intra building) tested for continuity and tagged at both ends with building number and ID number. All fibers tested for insertion loss, both directions, at 850nm and 1350nm on multi-mode, and at 1310nm and 1550nm on single-mode bi-directionally. All results documented and provided electronically. OTDR (Optical Time Domain Reflectometer) signature trace documents on all fibers with pertinent points documented (splice, endpoints, etc.) Only test results with Owner (ITS) personnel present will be accepted.

27 15 00 Communications Horizontal Cabling

27 15 01 Communications Horizontal Cabling Applications

27 15 01.19 Data/Voice Communications Horizontal Cabling

All workstations shall be fed by two (2) 4-pair, 100-ohm balanced, Category 6A plenum-rated cables with yellow jackets and matching color jacks. The cable manufacturer must be accepted by the proposed warranty. All Data/Voice cabling shall terminate in the nearest BDF/IDF serving the immediate area. No horizontal cable run shall exceed 90 meters. Cables shall be terminated at the workstation on Category 6A jacks and at the BDF/IDF on Category 6A patch panels. All cables must be tested and certified to Category 6A standards. The number and location of drops in computer labs, classrooms, and other special applications require input from NAU ITS. Only Velcro-type cable ties shall be used with structured cabling solutions.

- **All workstations shall consist of two (2) yellow Cat6A cables with matching color jacks.**
- **All cables shall be bundled in groups no larger than twenty-four (24) in the ceiling and all closets. When cables enter the closets or zone boxes, they shall be packed neatly (e.g., cigarette packing).**
- **All retrofit cabling terminations shall be T568-A.**
- **All new construction cabling terminations shall be T568-B.**

27 15 01.20 Wireless Access Point Data Communication Horizontal Cabling

Owner (NAU ITS) shall specify the wireless solution for the project/area served. The solution will include internal and external antennas (Cisco Aironet 2.4-GHz/5-GHz xMIMO 4-Element 802.11ax or as specified, Patch Antenna) and 802.11ax access points utilizing WISM 2 Controllers. Horizontal cabling shall be designed to meet a minimum -67 dB signal strength in all areas, typically achieved by placing AP locations at a 35-foot radius. Wireless design should be completed using the planning mode of the Ekahau Survey/Planning tool to generate locations that meet these parameters and any user requirements, such as increased client density in classrooms and large capacity spaces.

WAP (Wireless Access Points) locations should be positioned to allow horizontal mounting. All WAP locations shall consist of two (2) Category 6A yellow cables with matching color jacks. No permanent link run shall exceed 90 meters (295 feet). All installations shall adhere to current TIA TSB-162-A standards. All wireless cables shall be terminated T568-B on wireless-specific Cat6A patch panels, separate from station cable patch panels. All wireless cabling shall terminate in the BDF/IDF serving the immediate area.

The telecommunications installation contractor is responsible for mounting all WAPs (Wireless Access Points) and for telco room/station side patching on all installations. The contractor must provide an Excel spreadsheet detailing the location, patch panel ID, MAC address, and the location description or nearest room number.

27 15 43 Communications Faceplates and labeling.

Faceplates should be white in color and be populated in numerical order from top to bottom left to right.

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Labeling schema should be planned with NAU ITS to maintain consistency across each building but should contain the building Number, the Closet ID, the rack ID, the Patch panel ID, and the patch panel port. *Example format:* 54.1A.R1.A24

27 16 00 Communications Connecting Cords, Devices, and Adapters

27 16 13 Communications Custom Cable Assemblies

All custom-built cable assemblies shall be tested and certified to appropriate category level and meet performance level of all applicable codes and standards.

27 16 16 Communications Media Converters, Adapters, and Transceivers

Shall be furnished by Owner (NAU ITS).

27 16 19 Communications Patch Cords, Stations Cords, and Cross Connect Wire

Patch cords, equipment cords, and work area cords must be manufactured by the approved warranty provider and meet the applicable performance requirements in ANSI/TIA/EIA-568-B.2. All cords associated with the data horizontal cable system must be 4-pair UTP Category 6A rated, factory terminated, meet horizontal cable specifications, and shall be included in the System Warranty**.** All patch cords should be sized to provide a neat appearance with minimal excess length. Patch cord colors shall match the horizontal cabling.

27 20 00 DATA COMMUNICATIONS

27 21 00 Data Communications Network Equipment

All Data Communication Equipment furnished by Owner (NAU ITS).
E.g. Network switches, access points, power distribution units, and uninterrupted power supplies.

27 30 00 VOICE COMMUNICATIONS SWITCHING AND ROUTING EQUIPMENT

27 31 00 Voice Communications Switching and Routing Equipment

All equipment furnished by Owner (NAU ITS).

27 32 00 Voice Communications Telephone Sets, Facsimiles, and Modems

All telephone sets and ancillary equipment furnished by NAU ITS except emergency telephones.

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27 32 23 Elevator Telephones

All models shall be all-campus alert (ACA) capable and must be pre-approved by NAU ITS. All emergency phones to be fed by a minimum (1) 1" conduit suited for its environment and one (1) Category 6A rated cable suited for its environment with station protection and routed to the closest equipment room. Enclosure shall have electrical ground installed within 20 feet and the use of a gas discharge type lightning arrestor is required. The response time should be 1ns or less. If additional surge protection is needed, Surge Arrestor, Pt 800-1018 is required. Housing associated with elevator phones shall be grounded.

27 32 26 Ring-Down Emergency Telephones

All models shall be all-campus alert (ACA) capable and must be pre-approved by NAU ITS. All emergency phones to be fed by a minimum (1) 1" conduit suited for its environment and (1) Category 6A rated cable suited for its environment with station protection and routed to the closest telecommunications equipment room. Enclosure and columns shall have electrical ground installed within 20 feet and the use of a gas discharge type lightning arrestor is required. The response time should be 1ns or less. If additional surge protection is required, Surge Arrestor, Pt 800-1018 is required. Owner (NAU ITS) has pre-approved the following manufacturer(s): Ramtel.

27 33 00 Voice Communications Messaging

All services provided and maintained by NAU ITS.

27 34 00 Call Accounting

All services provided and maintained by NAU ITS.

27 35 00 Call Management

All services provided and maintained by NAU ITS.

27 40 00 AUDIO-VIDEO COMMUNICATIONS

All services provided and maintained by Owner (NAU ITS).

All AV installations and services shall be designed and installed in accordance with Division 27. See Design Guidelines for additional information on classroom standards.

****END OF SECTION****