Kennebec Valley Community College
CABLE PLANT SPECIFICATIONS

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SECTION A: DESIGN

A.1 OVERVIEW

KVCC has adopted cable plant specifications in order to build out a cable plant which will serve the College and maintain uniformity among the various buildings & sites owned and/or maintained by the College.

The specifications encompass both the inside cable plant (ICP) and outside cable plant (OCP). As technology and best practices change over time, the specifications are updated. In addition, there are parts of the cable plant which are considered "legacy" and some projects may interface with the "legacy" portions. Where such an interface is required, the contractor must design the interface and it must be approved by KVCC IT. In most projects, the budget does not support upgrading the legacy components.

Any deviation from the specifications below must be approved, in writing, by the Dean of Technology of the College and/or his/her authorized designee.

A.2 INSIDE CABLE PLANT (ICP)

A.2.1 WIRING - HORIZONTAL

A.2.1.1 OVERVIEW

Horizontal cabling provides connectivity between the horizontal cross-connect and the work-area telecommunications outlet. The horizontal cabling consists of the transmission media, the outlet, terminations of the horizontal cables and horizontal cross-connect at the IDF.

A.2.1.2 OUTLETS - DATA

All 100 Ohm UTP shall be wired to eight position modular jacks using T568B pin-out unless otherwise specified. All data outlet and patch panel jacks shall be Leviton QuickPort series parts (Leviton P/N 61110 series for jacks, Leviton P/N 69270-U48 for patch panels) unless signed off by KVCC IT. All data outlet jacks color must follow electrical outlet color scheme already defined in building.

Surface mounted boxes for data and voice outlets will be parallel-type, with built-in knockouts for mounting to raceway and number of RJ-45 compatible ports. All wiring devices and RJ-45 jacks should follow the TIA 568B configuration standard. Each data/voice outlet box will contain one spare port labeled spare.

All data outlet faceplates shall be Leviton Quickport series parts (Leviton P/N 42080 series), All faceplates color must follow electrical faceplace color scheme already defined in building or unless otherwise signed off by KVCC IT.

A.2.1.3 OUTLETS - VOICE

All voice outlets should be the same as the data outlets.

A.2.1.4 OUTLETS – VIDEO (COAX)

All coax video outlets shall be Leviton P/N 31084-FWF.

A.2.1.5 ROOM TYPE/REQUIRED OUTLET TYPE MATRIX

The following chart documents the type of outlets needed for each identified room type. Some specific rooms may require a deviation from the below chart; number of & location of outlets must be signed off by KVCC IT.

	Outlet Requirements				
Room Type	***PC (Data) Per device***	***Phone (Data) Per device***	***Printer (Data) Per device***	***Projector (Data)***	***TV (Coax)***
Classroom	X	X		X	X
Computer Lab	X	X	X	X	X
Science Lab	X	X		X	
Office	X	X			
Office (4+ Occ.)	X	X	X		
Conference Room/Meeting Area	X	X		X	X

The projector column represents the network connectivity needs, specific to the projector. For full projector cabling specifications, please review and adhere to the *Kennebec Valley Community College Projector Specifications*.

A.2.1.6 MEDIA TYPE

The media required for voice and data horizontal cabling is four pair 100 Ohm UTP Category 6* CMP rated. Any Cat6 cabling used must be certified Cat6 and rated for plenum use.

Color Scheme as follows:

Purpose	**Color**
Data	Blue/White
Voice	Blue/White
Security Cameras	Orange
Paging Systems	Purple

*single add-in drops should match cable specs already in building. Installing 5 or more drops in an area or area cable renovations requires minimum Cat6.

A.2.2 WIRING - VERTICAL

A.2.2.1 OVERVIEW

The purpose of the vertical wiring is to provide connectivity between distribution frames and entrance facilities. The following transmission media types may be used in the backbone cabling as noted on drawings or approved by KVCC IT.

A.2.2.2 MEDIA TYPE

- 100 Ohm Category 6* cable
- 50/125 um optical fiber Multi-mode fiber
- Single-mode Optical Fiber shall be 8.3/125

*Category 5 is acceptable in certain approved areas.

A.2.2.3 CABLE ROUTING

The following is a chart of minimum distances that UTP must be run from common sources of EMI (Electromagnetic interference):

Electromagnetic Interference Type	Minimum Distance
Fluorescent Lighting	24 in.
Neon Lighting	24 in.
Unshielded power cable, 2KVA or less	15 in.
Unshielded power cable, over 2KVA	39 in.
Motors, Transformers, etc	39 in.

Voice and data cabling should not be run parallel and adjacent to power cabling even at short distances unless one or both cable types are shielded and grounded. For current recommendations, refer to NEC/NFPA 70, Article 800-52.

All data and voice cabling is to be routed throughout buildings in single-channel cable tray (minimum 9" inside width), bridal rings, J-hooks, D-rings, or approved equal in concealed locations. Cable tray is preferred. D-rings are to be securely mounted to structure (wall, joists, etc.) and no more than five to six feet apart. Bridal rings and J-hooks no more than three feet apart and are to be securely mounted to structure (wall, joists, etc.).

Cable slack is to be in Telecommunication Rooms only, with no cable sags more than 6-inches anywhere between bridal rings, J-hooks, or D-rings. Install mounting hardware 2 feet above ceiling tiles unless otherwise approved by KVCC IT

Exposed non CMP rated fiber optic cabling will be placed in 1-inch CMP rated flexible innerduct for protection. Flexible innerduct must be fastened to a structure, by approved methods, above lay-in ceilings, with no sags laying on ceiling tiles. Fiber optic cabling runs in protected conduit will be run in plenum rated flexible multi cell textile innerduct system.

Plenum rated armored, or other similar type CMP rated backbone fiber optic cable, can be run parallel with data cable in the plenum returns. If exposed, the cable must be clearly labeled with a laminated cable ID tag every 40 feet, the tag must note the cable type and termination locations and be orange in color. Cable must also be clearly labeled on each end no more than two feet from termination box.

Velcro strips are to be used for securing cable bundles, cable ties are prohibited.

All cable, conduit and wire mold routings shall utilize the path of least obstruction and run parallel or perpendicular to existing walls. Hang multiple horizontal conduits in tight, vertically organized arrays and run vertical riser similarly. Avoid creating obstructions to future mechanical/electrical work.

Fiber optic cabling shall have no bends with a radius smaller than 20 times the outside diameter of the enclosing sheath. The minimum bend radius, under no-load conditions for four-pair unshielded twisted pair (UTP) cable, shall not be less

than four times the cable diameter or that which is recommended by the cable manufacturer.

From all individual data and voice outlets, run the appropriate cabling to the nearest intermediate distribution point.

The quantity and uses of cables needed at each receptacle location are as indicated on the drawings. Terminate each cable at the faceplate and in the appropriate patch panel in the appropriate intermediate distribution point. All exposed tag ends of cable terminations must be flush cut to factory specifications. Follow TIA 568B configuration for terminations.

Cabling shall meet or exceed the electrical specifications of ANSI/TIA/EIA 568-B.

A.2.3 DISTRIBUTION FRAMES & FACILITIES

A.2.3.1 OVERVIEW

KVCC is moving away from the terms of MDF & IDF and adopting the term 'CDF' (Consolidated Distribution Facility) to more accurately represent the practice at the College and realization that separate rooms for telecommunications, servers and wiring is, in most cases, not a possibility and services are being distributed across buildings for redundancy purposes.

New construction will utilize the term CDF while legacy buildings/facilities will maintain their designations of MDF or IDF.

A.2.3.2 CDF

The Consolidated Distribution Facility is a centralized space for all telecommunications equipment (voice, data & video) and termination of horizontal cabling.

CDFs should be designed to incorporate UPS systems, power backup circuits to diesel generators, and HVAC systems unless special exceptions are granted by KVCC IT.

In some cases, the BEF (Building Entrance Facility) may also serve as a CDF.

A.2.3.3 MDF

The Main Distribution Frame is a centralized space for all telecommunications equipment (voice, data & video). All requirements of entrance facility apply to MDF as well. Main Distribution Frames should be designed to incorporate UPS systems, power backup circuits to diesel generators, and HVAC systems.

A.2.3.4 IDF

The primary function of an IDF is to terminate horizontal cabling. All requirements of an entrance facility are required in an IDF as well. The IDF's may be used to cross connect horizontal as well as backbone cabling together. UPS systems and generated backup circuits are required for every IDF.

A.2.3.2 ENVIRONMENT

Environmental control equipment, such as power distribution/conditioner, Large scale UPS systems, and HVAC must be provided.

A.2.4 PATCH PANELS, CROSS CONNECTS, & OUTLETS

Patch panels for data are to be Leviton QuickPort series parts such as Leviton P/N 69270-U48. Patch cables shall be UTP Cat6 24 AWG stranded with snagless RJ-45 connectors.

Color Schemes:
- Blue - data
- White – voice (for legacy integrations)
- Orange – security devices
- Purple – paging systems
- Grey – cross over

Cat6 patch cables should be long enough to properly be routed through cable management systems and inserted into jacks without stretching cables. It might be necessary to use various length cables even in same rack system. One patch cable shall be provided for each connector in patch panel.

Fiber patch cables should conform to existing connector (SC, ST, LC)/mode (single or multimode) type already installed in fiber shelf and network device when connecting to existing/legacy infrastructure.

Color Scheme:
- Orange - 1GB links
- Turquois - 10GB uplinks

New fiber termination enclosures must contain an appropriate number of fiber cross connect SC, ST, LC type connectors for interconnection of fibers between wiring closets. Enclosures must be able to be mounted in a 19-inch equipment rack. Enclosures are to contain a front accessible, hinged, slide-out tray with SC, ST, LC connectors on front and strain relief ring for excess fiber cabling in back of tray. Rack mounted fiber enclosures shall be manufactured by Leviton.

Telecommunication Standards ANSI/TIA/EIA-568-B, TIA/EIA-568-B.1, T568B must be followed unless otherwise noted.

A.2.5 EQUIPMENT RACKS, CABLE MANAGEMENT & RACEWAYS

A.2.5.1 EQUIPMENT RACKS

All telecommunication rooms must be equipped with a minimum of two (2) 19” black aluminum relay racks which are anchored to the floor. Each rack is to be supported from the wall with a standard 12” black cable runway ladder rack. The ladder rack is to be anchored to the wall and the rack using industry standard mounting hardware.

The ladder will be used to support the racks and also to transition the cables to the rack space. No cable will free span from the wall to the racks.

A.2.5.2 CABLE MANAGEMENT

Cable management panels are to be utilized to organize excess slack cable lengths at rack locations. Furnish one (1) 2U cable management panel per 48 port patch panel, plus one (1) additional 2U management panel. Management panels must be able to be mounted in an EIA 356 standard 19-inch rack, and provide both horizontal and vertical wire management.

A.2.5.3 RACEWAYS

All new wiring devices, data and voice outlets, etc., that are shown to be installed on existing walls and surfaces are to be installed in metallic raceways. Raceways to be UL listed for electrical wiring up to 300V , and furnished with all boxes,

faceplates, connectors, corners, angles, tees, etc., as required to install all devices as shown on drawings.

Raceways are to be securely mounted to walls with screws anchored into walls. Screws must be drilled into base of raceway 12 inches apart on center.

A.2.6 TELCOMMUNCATIONS WIRING

Termination panels for legacy telco are to be 110-type punch down blocks.

All exterior runs of voice backbone cabling to be lightning protected. Lightning protection units to utilize 110-type connection system and must be UL certified and UL 497B listed. Lightning protectors shall utilize gas-discharge modules with over-voltage protection.

A.3 OUTSIDE CABLE PLANT (OCP)

A.3.1 Overview

KVCC has a standard for inter-building connectivity which is currently in use.

The College utilizes an infrastructure built out on the Cisco platform and utilizes multiple strands of single-mode fiber to connect buildings together given the longer distances between buildings.

In addition to Fiber-based services (data & voice), the College utilizes both Copper "Trunk" cables for alarm & control systems as well as Coax cable for CableTV, internal CCTV & other video services.

As a standard guide, the cabling is determined by the type of building that is being connected:

Building Type	Fiber	Copper "Trunk"	Coax
Primary	Min 12 Strands SMF	Min 100 Pair	Required
Ancillary	6 Strands SMF	25 Pair	Optional
Primary Residence Hall	TBD	TBD	TBD
Ancillary Residence	4 Strands SMF (Opt.)	25 Pair	Required

Primary buildings include main classroom buildings or main administrative type buildings. Ancillary buildings include specialized classroom buildings (in this particular case the Farm) and smaller administrative/operational buildings.

The outside cable plant (OCP) provides inter-building pathway(s) for communications cable(s). The OCP is typically a combination of a number of conduit runs, pull boxes and access points for maintenance herein referred to as the Maintenance Hole (MH)

The Outside Plant Conduit System must be designed and installed to the NESC and ANSI/EIA/TIA-758 and 758-1 Specifications for Outside Plant Construction.

A.3.2 CONDUITS

Each building shall have, at a minimum, three trade 4-size conduits for routing communication cables into the building. The number of conduits may be increased for multi-story buildings where larger backbone cables must be routed.

- Conduits are to be schedule 40 PVC or equivalent.

- At least one conduit will contain a sub-channel system or contain three innerduct.
- The conduit runs will contain no more than two 90 degree turns or cumulatively 180 degrees of bend between maintenance holes (MH) and the termination point in the Building Telecommunications Room. This includes kicks, offsets and the turn from horizontal to vertical when entering the Telecommunications Room from below.
- If the conduits penetrate from below, the conduits will stub up at least 4-inches
- If the walls of the Telecommunications room are penetrated, the conduits shall stub out 1 to 2 inches and conduits shall pass through the wall at an upward angle so water will not drain into the room.

  Note: KVCC prefers conduits enter above ground-level in the designated communications room/BEF.

- The conduits will have plastic bushings at the building side end
- A 3/8" nylon pull rope with a minimum of 200 lbs. of pulling tension will be in all conduits and or innerduct.
- Measurement (true tape) in one conduit in a multi-conduit run
- All conduits, sub-channel and/or innerducts shall be sealed at the building end to prevent insects, rodents, water or gases from entering the building.

A.3.2.1 UNDERGROUND ROUTES

Underground routes must be designed and documented on engineering drawings. These drawings must include the following information:

- Details of typical trench cross sections showing duct locations in the trench, clearances from final grade, backfill materials and depths, pavement cutting information, and compacting requirements for both paved and unpaved areas
- Construction notes applicable to the work being performed
- A scale drawing showing location ties to existing structures, cable, conduit, utility boxes, and any conflicting substructures and profile drawings of congested areas where vertical and horizontal separation from other utilities is critical during cutting and placing operations and any other areas as requested by KVCC
- A legend explaining symbols of all relevant structures and work operations
- Conduit types, dimensions, and wall-to-wall measurements when used with MH, Pedestals, electrical rooms and Telecommunications Rooms
- Warning tape containing metallic tracings must be placed a minimum of 12 inches above the underground conduit/duct structure and direct buried cable to minimize any chance of an accidental dig-up. The American Public Works Association has adopted the color orange for the telecommunications cables. Both ends of the metallic warning tape will be assessable from both ends after installation.
- The minimum depth of a trench must allow 24 inches of cover from the top of the conduit/cable to final grade for conduits that traverse areas with no vehicular traffic. Depth must be increased with the increasing incidence of vehicular traffic to a maximum of 6 feet for constant traveled roadways. Conduits that route underneath pedestrian

pathways that also support vehicular traffic must be buried with appropriate depths, so that maintenance vehicles or Fire trucks driving over the pathways will not inadvertently crush the underground conduits.

- Conduits shall be designed so that changes in cable routing direction occur outside of the maintenance hole. Bends must occur at least 20 feet away from the box. No bends greater than 90 degrees are permitted. Reversals of conduit path are not allowed.

- Local underground utilities must be contacted 72 hours prior to excavation. A Dig Safe ticket number must be present and on site during any construction, and utilities located before digging to locate all subsurface facilities such as power, gas, water and outdoor lighting.

- Conduit penetration of a building must be located so that the outside plant cable termination area is within 50 feet of the point of penetration. If the cable must extend inside the building for greater than 50 feet, it must be encased in Rigid or Intermediate conduit that does not expose the cable for more than 50 feet. The Rigid or Intermediate conduit must conform to the same requirements of requiring a pull box after two 90 degree or cumulatively 180 degrees of bend. From the point of the first pull box, the outside plant cable can only run 50 feet until its termination point. The cable length includes routing and service loop lengths

- All conduits in a duct bank that enter a Maintenance Hole or Building shall be sealed at the time of installation to prevent the intrusion of liquid or gases into the MH or Building. Seal after pull rope is installed. During cabling, the seals will be broken and resealed in a comparable fashion after cable installation, testing and acceptance is completed

- Per ANSI/TIA/EIA-758 a drain slope of 0.125 inches per foot toward the HN/HH shall be provided.

- The following table shows the vertical or horizontal separations that must be maintained between telecommunications facilities and other facilities sharing a common trench.

Adjacent Structure	Minimum Separation
Power or other foreign conduit	3 inches of concrete, or 4 inches of masonry, or 12 inches of well-tamped earth
Pipes (gas, oil, water, etc…)	6 inches when crossing perpendicular 12 inches when parallel

A.3.2.2 MAINTENANCE HOLES (MH)

Maintenance holes are required at specific distances in order to pull and splice cables in an underground/concealed location.

Maintenance Holes are required:

  - When the conduit section length exceeds 500 ft
  - Wherever a cable splice may be required as defined by KVCC IT
  - Where bends exceed a total of 180 deg. or two bends of 90 deg.

- Maintenance Holes must be sized according to the College's specifications for each project and/or location.
- Concrete used for maintenance holes shall be of at least 3500 sq lb/in strength rating

- All MH's will be properly grounded as required by EIA/TIA standards and the NEC
- All MH's will be equipped with a cover & labeling indicating "COMMUNICATIONS LINES ONLY"
- Conduits entering a MH will do so through the MH walls designed for conduit penetration so that the structural integrity of the MH is not compromised
- Conduits being added to a MH are to start at the bottom and be added in ascending order to accommodate future expansion
- Where distances between MHs exceeds 300 ft or there are more than 2, 90 deg. bends, a 4' x 4' x 4' pull box is to be utilized

A.3.2.3 BUILDING MAINTENANCE HOLES (BMH)

Building Maintenance Holes are required before entering a building thru the BEF when the conduit run continues or is planned to be continued to a further outlying building.

The BMH's have the same requirements as the normal MH's except that generally larger and act as a three(3)-way junction point in the conduit runs.

A.3.3 BUILDING ENTRANCE FACILITY (BEF)

The BEF is the point at which the outside conduits and associated backbone cables enter & leaving a building. A BEF may be located in a MDF, IDF or at last resort, a mechanical room.

- In compliance with the NEC, the entrance of outside building cables shall be terminated and protected on a listed primary protector within 50 ft of entering the building unless encased in conduit within the building
- This room/local shall be sized to reflect the amount of outside cabling that will be terminated. The architecture and/or engineer shall get this information from the KVCC IT department.
- Cables entering shall be terminated on protectors mounted to one wall of the BEF. From these protectors, cable shall travel via conduits and/or cable trays.
- The BEF requires building air conditioning
- The BEF shall have a minimum of four (4) dedicated 15A, 100V AC duplex outlets

A.3.3.1 ELECTRICAL CIRCUITS

See section D.1.2

A.3.3.2 WALL-MOUNTED BACKBOARD

Backboard is utilized to terminate cables entering the BEF. The backboard must be flame retardant A-C plywood and be mechanically fastened to the wall of the BEF. All plywood used for the purposes of backboard should be treated with two coats of black, flame retardant paint.

A.3.3.3 SECURITY

All telecommunications facilities, including the BEF must be kept secure behind a locked door; primary access is to be thru the door control system via proximity badge restricted to authorized KVCC IT personnel only.

A.3.3.4 LIGHTING

Lighting in the BEF shall be a minimum of 50 foot candles (500 lux) measured 3 feet above floor. Lighting is to be achieved using fluorescent lamps and to be controlled by a switch located immediately inside the door of the BEF.

A.3.3.5 APPLICABLE STANDARD(S)

TIA/EIA-569-A must be followed unless a deviation is authorized by KVCC IT.

A.3.4 FIBER SPECIFICATIONS

A.3.4.1 OVERVIEW

Fiber Optic terminations shall be consistent with existing fiber terminations in an area. If fiber is being terminated in a location where no fiber exists, it should be termination in a 19" rack mounted fiber enclosure. See A.2.4. All fibers must be terminated and tested unless otherwise approved by KVCC IT. Terminations shall be of type SC for the Fairfield Campus and LC for the Alfond Campus.

Fiber is to;

- Meet or exceed Underwriters Laboratory 1666 (UL-1666) requirements
- Fibers are separated into color-coded binder groups inside a central tube filled with water-blocking compound
- The sheath has dielectric strength member parallel to the core and outside the core
- The sheath jacket material (color: black) is medium-density polyethylene for maximum environmental protection and is petrochemical stable
- The designation "UL®" shall be printed every two (2) feet on the cable jacket
- The cable shall have individual fiber tube colors per TIA/EIA-598-B
- The cable shall be suitable for temperatures of -40 to +75 Celsius

A.3.4.2 MULTIMODE

Multimode Fiber Cables shall:

- Be graded-index optical fiber with nominal 50/125µm-core/cladding diameter
- Shall conform to the composition specified for Laser Optimized Multimode Fiber specifications ANSI/EIA/TIA 492AAAC as well as the OM3 specifications in ISO/IEC 11801 2nd Edition and EN50173 2nd Edition.
- Meet the graded performance specifications below. Testing of the optical fiber shall be in accordance with TIA/EIA 526-14A, using power meter testing Type B. The measurements shall be performed at 23 degrees C +/- 5 degrees.

Maximum Attenuation	Minimum Bandwidth
3.5 dB/km @ 850 nm	1500 MHz.km @ 850 nm
1.5 dB/km @ 1300 nm	500 HMz.km @ 1300 nm

The performance characteristics of the fiber shall also comply with those specified in TIA/EIA-568-B.3.1 Addendum 1 – Additional Transmission Performance Specifications for 50/125 µm Optical Fiber Cables.

A.3.4.3 SINGLE MODE

Single Mode Fiber Cables shall be:

- Class IVa Dispersion-Unshifted single mode optical fibers complying with ANSI/EIA/TIA-492BAAA
- The zero dispersion wavelength shall be between 1300 nm and 1324 nm. The ANSI/EIA/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.093 ps/km-nm2. Dispersion measurements shall be made in accordance with ANSI/EIA/TIA-455-169 or ANSI/EIA/TIA-455-175
- The nominal core diameter shall be 8.3 µm to 10.0 µm with a tolerance of +/- 0.5 um at 1300 nm when measured in accordance with ANSI/EIA/TIA-455-164 or ANSI/EIA/TIA- 455-167
- Meet the graded performance specifications below. Testing of the optical fiber shall be in accordance with TIA/EIA 526-7, using testing Type A.1. The measurements shall be performed at 23 degrees C +/- 5 degrees

Maximum Attenuation	Cable Type
1.0 dB/km @ 1310/1550 nm	Riser (inside) Plant
0.50 dB/km @ 1310/1550 nm	Outside Plant

SECTION B: INSTALLATION

B.1 INSTALLATION GUIDELINES

B.1.1 FIBER OPTIC CABLES

All fiber optic cable shall be installed within innerduct.

- Use pulling compound when necessary; pulling compound must be a water-base pulling lubricant that will not deteriorate the cable or conduit.
- All cable/cabling shall be kept 30 inches away from any heat source; i.e., steam valves, etc.
- Cables shall be pulled free of sharp bends, kinks, twists, or impact damage to the sheath
- Cables shall not be pulled across sharp edges. All conduits and sleeve with rough edges will be provided with bushings on both ends. Cables shall not be forced or jammed between metal parts, assemblies, etc.
- Cables shall not be pulled across access doors and pull box covers. Access to all equipment and systems must be maintained
- Cable splicing will not be permitted at any point within a cable run unless specifically approved by KVCC IT
- Conduits will not be filled to greater than a 40% fill
- Outside Plant Conduits must have appropriately size pull-boxes every 300 feet. When the conduit routes through up to a total of two 90 degree bends (180 degrees total) in any dimension plane, additional pull-boxes are also required. Cabling will not be installed in conduits that do not meet these specifications.
- Backbone cables will be installed with a 30 foot service loop. The service loops will be coiled neatly in the nearest maintenance hole, pull box or hand-hole to the building's exterior wall.
- Cable mountings and service loops on backboards inside Information Technology Rooms will be installed efficiently to minimize the backboard space consumed. All cables will be routed at right angles, in accordance with the bend radius specifications for the type of cable being routed. Cables will be velcro-wrapped every 4 to 6 feet.
- Polarization for entire system shall be maintained as described in ANSI/EIA/TIA-568-B section 12.7.1.
- All optical fiber cables shall be terminated on rack-mounted optical fiber patch panels. No fiber will be left unterminated unless specifically stated by KVCC.

B.1.1.1 FIBER OPTIC TERMINATIONS

Fiber Patch Panels

Optical fiber patch panels shall meet or exceed the following specifications:

- Must be rack mounted
- Must be configured in duplex SC style termination configurations
- Must be completely covered
- Must be available as a high-density shelf for Main and Building Telecommunication Room installations, or 24-connector 1U trays for smaller Telecommunication room backbone terminations where fiber counts are less that 24 fibers

Optical Fiber Connectors

Field termination is required for **all** fiber strands in the telecommunications closets. No fiber is to be left unterminated.

- All connectors are to be glass-in-ceramic ST (Fairfield campus) or LC (Alfond campus)-compatible field-installable duplex connectors
- Connectors shall meet ANSI/EIA/TIA-604-10 standards
- Connectors must have a locking feature to the coupler to prevent optical disconnect
- The connector shall have an optical axial pull strength of 2.2 N at 0 degree angle and an optical off axial pull strength of 2.2 N at a 90 degree angle, with a maximum 0.5 dB increase in attenuation for both tests when tested in accordance with ANSI/EIA/TIA 455-6B
- Adhere to all manufacturer installation guidelines
- The maximum optical attenuation per each mated field installed connector pair shall not exceed 0.75 dB
- The total optical attenuation through the cross-connect from any terminated optical fiber to any other terminated fiber shall not exceed 1.5 dB
- Multimode fiber shall have a return loss greater than or equal to 20 dB
- Single mode shall have a return loss greater than or equal to 26 dB
- The connectors shall sustain a minimum of 500 mating cycles without degrading this performance

B.1.1.2 INNERDUCT

All fiber backbone cabling shall be installed in innerduct. For outside plant installations, the innerduct will be smooth walled, high density polyethylene. The innerduct will be orange in color and 1-½ inch in diameter. For all new installations of fiber backbone, a minimum of one extra innerduct will be installed parallel to the new cabling installation.

Where new conduit infrastructure is installed with unused conduits, at least one of the unused conduits will be filled with innerduct tubes, providing a partitioning of the conduit for future cable installations. All innerduct tubes shall be equipped with a 3/8” nylon pull rope, to facilitate future cabling installations.

B.1.2 COPPER CABLES

- Use pulling compound when necessary; pulling compound must be a water-base pulling lubricant that will not deteriorate cable or conduit. Adhere to all manufacturers’ requirements regarding pulling tension and allowable lubricants.
- All cable/cabling shall be kept 30 inches away from any heat source; i.e., steam valves, etc.
- Cables shall be pulled free of sharp bends, kinks, twists, or impact damage to the sheath
- Cables shall not be pulled across sharp edges. All conduits and sleeve with rough edges will be provided with bushings on both ends. Cables shall not be forced or jammed between metal parts, assemblies, etc

- Cables shall not be pulled across access doors and pull box covers. Access to all equipment and systems must be maintained
- Cable splicing will not be permitted at any point within a cable run
- All outside plant backbone cables will be installed in conduit. Aerial runs are generally not permitted unless an exception is granted by KVCC.
- Conduits will not be filled to greater than a 40% fill
- Conduits must have appropriately size pull-boxes every 300 feet. When the conduit routes through up to a total of two 90 degree bends (180 degrees total) in any dimensional plane, pull-boxes are also required. Cabling will not be installed in conduits that do not meet these specifications.
- Backbone cables will be installed with a 30 foot service loop. At each building , the service loops will be coiled neatly in the pull box or nearest hand hole on the building's exterior wall. Cable mountings and service loops on backboards will be installed efficiently to minimize the backboard space consumed. All cables will be routed at right angles, in accordance with the bend radius specifications for the type of cable being routed. Cables will be velcro-wrapped every 4 to 6 feet.
- Cable shall be continuous and without splices (Splices imply same pair count cable splices: i.e.: 200-pair to 200-pair)
- Verify all actual cable distances

B.1.2.1 COPPER TERMINATIONS

All **new** copper backbone cables will be terminated on rack-mounted patch panels, one pair per RJ-45 jack. This will facilitate moves and changes via patch cords from the station jack instead of cross-connect wire.

Punch down blocks will be used for cross-connect of **existing** copper backbone. Blocks shall meet or exceed the following specifications:

- 110 style termination blocks
- 100- or 300-pair blocks as appropriate for the density of the terminations
- Labeled per ANSI/TIA/EIA-606-A
- Supplies with connecting clip, designation strip, plastic covers and retaining clip necessary to terminate cables, including but not limited to:
    - 4-pair connecting clip for horizontal copper cabling (When terminating 4-pair cables)
    - 5-pair connecting clip for backbone copper cabling (When terminating high pair count copper cables)
    - Installed on plywood backboard

SECTION C: TESTING & DOCUMENTATION

C.1 TESTING AND DOCUMENTATION REQUIREMENTS

C.1.1 OVERVIEW

Contractor must supply to KVCC IT a completed set of cable test records. The records shall indicate run numbers, room numbers, patch panel numbers, port numbers, cable length, pair 1 test, pair 2 test, pair 3 test, pair 4 test, ground test and the name of technician performing the tests and the date and time of the test. Testing shall be per IEEE Standards and TIA/EIA TSB-67 and shall include, but not be limited to, these tests:

1. Resistance
2. Impedance
3. Relative power loss test for fiber optic cable (where present)
4. Near-end cross talk
5. Length verification using time-domain reflectometer testing
6. Proper pinning/termination
7. Tension testing during installation for fiber optic cable (where present)

Unsatisfactory test results will require the electrical contractor to correct the system, at no cost to KVCC, before acceptance of the work will be given.

The following items will be tested for operational performance:

1. Unshielded twisted pair cable for voice and data
2. Fiber-optic cable (if present)
3. Passive network components
4. Miscellaneous supporting equipment

End to end continuity, performance and diagnostic test should be the final test performed in all cases.

C.1.2 CATEGORY 6 UTP TESTING

C.1.2.1 GENERAL REQUIREMENTS

1. Every cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA/EIA-568-B.2-1
2. The installed twisted-pair horizontal links shall be tested from the telecommunications room to the telecommunication wall outlet in the work area against the *"Permanent Link"* performance limits specification as defined in ANSI/TIA/EIA-568-B.2-1.
3. One hundred percent of installed cabling links must be tested and must pass the requirements of the standards mentioned above. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation.
4. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. Appropriate training programs include but are not limited to

installation certification programs provided by BiCSi or the ACP (Association of Cabling Professionals). Technician's certification must be made available upon request.

5. The test equipment (tester) shall comply with the accuracy requirements for level III field testers as defined in the TIA Cat 6 Document. The tester including the appropriate interface adapter must meet the specified accuracy requirements. The accuracy requirements for the permanent link test configuration (baseline accuracy *plus* adapter contribution) are specified in Table B.2 of Annex B of the TIA Cat 6 Standard. (Table B.3 in this TIA document specifies the accuracy requirements for the Channel configuration.)

6. The test plug shall fall within the values specified in E.3.2.2 Modular test plug NEXT loss requirements of the TIA Cat 6 Standard.

7. The tester shall be within the calibration period recommended by the manufacture in order to achieve the manufactures specified measurement accuracy.

8. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests. Any Fail or Fail* result yields a Fail for the link-under-test. In order to achieve an overall Pass condition, the results for each individual test parameter must Pass or Pass*.

9. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter. The test result of a parameter shall be marked with an asterisk (*) when the result is closer to the test limit than the accuracy of the field tester. The field tester manufacturer must provide documentation as an aid to interpret results marked with asterisks.

C.1.2.2 TESTING PARAMETERS

The test parameters for Cat 6 are defined in TIA Cat 6 standard, which refers to the ANSI/TIA/EIA-568-B.2 standard. The test of each link shall contain all of the following parameters as detailed below. In order to pass the test all measurements (at each frequency in the range from 1 MHz through 250 MHz) must meet or exceed the limit value determined in the above-mentioned standard.

1. **Wire Map:** Wire Map shall report Pass if the wiring of each wire-pair from end to end is determined to be correct. The Wire Map results shall include the continuity of the shield connection if present.

2. **Length:** The field tester shall be capable of measuring length of all pairs of a basic link or channel based on the propagation delay measurement and the average value for NVP (1). The physical length of the link shall be calculated using the pair with the shortest electrical delay. This length figure shall be reported and shall be used for making the Pass/Fail decision. The Pass/Fail criteria are based on the maximum length allowed for the Permanent Link configuration (90 meters – 295 feet) plus 10% to allow for the variation and uncertainty of NVP.

3. **Insertion Loss (Attenuation):** Insertion Loss is a measure of signal loss in the permanent link or channel. The term "Attenuation" has been used to designate "Insertion Loss." Insertion Loss shall be tested from 1 MHz through 250 MHz in maximum step size of 1 MHz. It is preferred to measure insertion loss at the same frequency intervals as NEXT Loss in order to provide a more accurate calculation of the Attenuation-to-Crosstalk ratio (ACR) parameter. Minimum test results documentation (summary results): Identify the worst wire pair (1 of 4 possible).

   The test results for the worst wire pair must show the highest attenuation value measured (worst case), the frequency at which this worst case value occurs, and the test limit value at this frequency.

4. **NEXT Loss:** Pair-to-pair near-end crosstalk loss (abbreviated as NEXT Loss) shall be tested for each wire pair combination from each end of the link (a total of 12 pair combinations). This parameter is to be measured from 1 through 250 MHz. NEXT Loss measures the crosstalk disturbance on a wire pair at the end from which the

disturbance signal is transmitted (near-end) on the disturbing pair. The maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the standard as shown in Table 1, column 2. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst case NEXT margin (2) and the wire pair combination that exhibits the worst value of NEXT (worst case). NEXT is to be measured from each end of the link-under-test. These wire pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

Frequency Range (in MHz)	Maximum Step Size (in MHz)
1 – 31.25	0.15
31.26 – 100	0.25
100 - 250	0.50
250 – 350	1.00

5. **PSNEXT Loss:** Power Sum NEXT Loss shall be evaluated and reported for each wire pair from both ends of the link under-test (a total of eight results). PSNEXT Loss captures the combined near-end crosstalk effect (statistical) on a wire pair when all other pairs actively transmit signals. Like NEXT this test parameter must be evaluated from 1 through 250 MHz and the step size may not exceed the maximum step size defined in the standard as shown in Table 1, column 2.

   Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSNEXT. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

6. **ELFEXT Loss, pair-to-pair:** Pair-to-pair FEXT Loss shall be measured for each wire-pair combination from both ends of the link under-test. FEXT Loss measures the crosstalk disturbance on a wire pair at the opposite end (far-end) from which the transmitter emits the disturbing signal on the disturbing pair. FEXT is measured to compute ELFEXT Loss that must be evaluated and reported in the test results. ELFEXT measures the relative strength of the far-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire pair combinations. ELFEXT is to be measured from 1 through 250 MHz and the maximum step size for FEXT Loss measurements shall not exceed the maximum step size defined in the standard as in Table 1, column 2.

   Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ELFEXT. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

7. **PSELFEXT Loss:** Power Sum ELFEXT is a calculated parameter that combines the effect of the FEXT disturbance from three wire pairs on the fourth one. This test yields eight wire-pair combinations. Each wire-pair is evaluated from 1 through 250 MHz in frequency increments that do not exceed the maximum step size defined in the standard as shown in Table 1, column 2. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

8. Return Loss: Return Loss (RL) measures the total energy reflected on each wire pair. Return Loss is to be measured from both ends of the link-under-test for each wire pair. This parameter is also to be measured form

1 through 250 MHz in frequency increments that do not exceed the maximum step size defined in the standard as shown in Table 1, column 2.

Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for Return Loss. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

9. **ACR (Attenuation to crosstalk ratio)** [This parameter is not demanded by the standard but may be required in order to obtain the premise wiring manufacturer's warranty]**:** ACR provides an indication of bandwidth for the two wire-pair network applications. ACR is a computed parameter that is analogous to ELFEXT and expresses the signal to noise ratio for a two wire-pair system. This calculation yields 12 combinations – six from each end of the link. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR. These wire pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

10. **PSACR** [This parameter is not required by the standard but may be required in order to obtain the premise wiring vendor's warranty]**:** The Power Sum version of ACR is based on PSNEXT and takes into account the combined NEXT disturbance of all adjacent wire pairs on each individual pair. This calculation yields eight combinations –one for each wire pair from both ends of the link. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSACR. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

11. **Propagation Delay:** Propagation delay is the time required for the signal to travel from one of the link to the other. This measurement is to be performed for each of the four wire pairs. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay. The report shall include the propagation delay value measured as well as the test limit value.

12. **Delay Skew** [as defined in TIA/EIA-568-B.1; Section 11.2.4.11]**:** This parameter shows the difference in propagation delay between the four wire pairs. The pair with the shortest propagation delay is the reference pair with a delay skew value of zero. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay (the longest propagation delay). The report shall include the delay skew value measured as well as the test limit value.

C.1.3 FIBER TESTING

C.1.3.1 GENERAL

Contractor is to provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in project documents.

In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

All installed cabling links and channels shall be field-tested and pass the test requirements and analysis. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation.

C.1.3.2 SCOPE

This section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.

Testing shall be performed on each cabling link (connector to connector). Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters or optical amplifiers. All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode and single mode links and channels and OTDR traces and event tables for multimode and single mode links and channels. Documentation shall also include optical length measurements.

C.1.3.3 QUALITY ASSURANCE

All testing procedures and field-test instruments shall comply with applicable requirements of:

- ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
- ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements
- ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.
- ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR.
- ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.
- ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Single mode Fiber Cable Plant.
- ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
- ANSI/TIA/EIA-568-B.1, Commercial Building Telecommunications Cabling Standard, Part 1, General Requirements.
- ANSI/TIA/EIA-568-B.3, Optical Fiber Cabling Components Standard.
- TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems.

C.1.3.4 TESTING CERTIFICATIONS

Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

- Manufacturer of the fiber optic cable and/or the fiber optic connectors.
- Manufacturer of the test equipment used for the field certification.
- Training organizations (e.g., BICSI)

Technician's certification must be made available upon request.

C.1.3.5 TESTING SPECIFICATIONS

Optical loss testing

- The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA-568-B.1:
- Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)
- Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)
- Connector_Attn (dB) = number_of_connector_pairs * connector loss (dB)
- Maximum allowable connector loss = 0.75 dB

- Splice_Attn (dB) = number_of_splices * splice_loss (dB)
- Maximum allowable splice_loss = 0.3 dB

Attenuation_Coefficient (dB/km) values:

Optical Fiber Type	Wavelength (nm)	Attenuation Coefficient (db/km)
Multimode 62.5/125 µm	850	3.5
Multimode 62.5/125 µm	1300	1.5
Multimode 50/125 µm	850	3.5
Multimode 50/125 µm	1300	1.5
Single-mode (ICP)	1310	1.0
Single-mode (ICP)	1550	1.0
Single-mode (OCP)	1310	0.5
Single-mode (OCP)	1550	0.5

OTDR testing

- Reflective events (connections) shall not exceed 0.75 dB.
- Non-reflective events (splices) shall not exceed 0.3 dB.

Magnified end face inspection

- Fiber connections shall be visually inspected for end face quality.
- Scratched, pitted or dirty connectors shall be diagnosed and corrected.

C.1.3.6 TESTING PROCEDURE

All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.

All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

Optical fiber cable testing

1. Field-test instruments shall have the latest software and firmware installed.

2. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

3. Fiber end faces shall be inspected at 250X or 400 X magnifications. 250X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

4. Testing shall be performed on each cabling segment (connector to connector).

5. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.

6. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR

testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

Optical loss testing

1. Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper or the equivalent method.

2. Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method.

3. Link attenuation does not include any active devices or passive devices other than cable, connectors and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters or optical amplifiers.

4. Use the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1 or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.

OTDR testing

1. A launch cable shall be installed between the OTDR and the first link connection.

2. A receive cable shall be installed after the last link connection.

Magnified endface inspection

Fibers shall be inspected at 250X or 400 X magnifications. 250X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers.

Length measurement

1. The length of each fiber shall be recorded.

2. It is preferable that the optical length be measured using an OLTS or OTDR.

Polarity testing

Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with sub clause 10.3 of ANSI/TIA/EIA-568-B.1. The polarity of the paired duplex fibers shall be verified using an OLTS.

C.1.4 DELIVERY FORMAT FOR TESTING RESULTS

1. The test results information for each link shall be recorded in the memory of the field test equipment upon completion of the test.

2. The test results records saved by the tester shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred to the PC unaltered, i.e., "as saved in the tester" at the end of each test and that these results cannot be modified at a later time. Superior protection in this regard is offered by testers that transfer the numeric measurement data from the tester to the PC in a non-printable format.

3. The database for the completed job shall be stored and delivered on CD-ROM or DVD including the software

tools required to view, inspect and print any selection of test reports.

4. A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information:

   - The identification of the link in accordance with the naming convention defined in the overall system documentation
   - The overall Pass/Fail evaluation of the link-under-test including the NEXT Headroom (overall worst case) number
   - The date and time the test results were saved in the memory of the tester.
   - Name of technician performing tests.

5. General Information to be provided in the electronic data base with the test results information for each link:

   - The identification of the customer site as specified by the end-user
   - The identification of the link in accordance with the naming convention defined in the overall system documentation
   - The overall Pass/Fail evaluation of the link-under-test
   - The name of the standard selected to execute the stored test results
   - The cable type and the value of NVP used for length calculations
   - The date and time the test results were saved in the memory of the tester
   - The brand name, model and serial number of the tester
   - The identification of the tester interface
   - The revision of the tester software and the revision of the test standards database in the tester
   - The test results information must contain information on each of the required test parameters that are listed in Section I.B and as further detailed below under paragraph I.C6.

6. The detailed test results data to be provided in the electronic database:

- For each of the frequency-dependent test parameters:
- The value measured at every frequency during the test is stored. In this case, the PC-resident database program must be able to process the stored results to display and print a color graph of the measured parameters.
- The PC-resident software must also provide a summary numeric format in which some critical information is provided numerically as defined by the summary results (minimum numeric test results documentation) as outlined above for each of the test parameters.
- Data for each tested link must contain the following information:
- Length: Identify the wire-pair with the shortest electrical length, the value of the length rounded to the nearest 0.1 m (1) and the test limit value.
- Propagation delay: Identify the pair with the shortest propagation delay, the value measured in nanoseconds (ns) and the test limit value.
- Delay Skew: Identify the pair with the largest value for delay skew, the value calculated in nanoseconds (ns) and the test limit value.
- Attenuation: Minimum test results documentation as explained in Section I.B for the worst pair.
- Return Loss: Minimum test results documentation as explained in Section I.B for the worst pair as measured from each end of the link.
- NEXT, ELFEXT, ACR: Minimum test results documentation as explained in Section I.B for the worst pair combination as measured from each end of the link.
- PSNEXT, PSELFEXT and PSACR: Minimum test results documentation as explained in Section I.B for the worst pair as measured from each end of the link.

C.1.5 AS-BUILT DRAWINGS AND CONFIGURATION FILES

The contractor shall record all changes and deviations from the contract drawings, with special emphasis on the exact location of all underground facilities by offset distances to surface improvements such as building corners, curbs, etc. Entries and notations shall be neat, legible and permanent. These prints shall be delivered to KVCC IT upon completion of any project.

C.1.6 MANUALS – MAINTENANCE & USER

At completion of a project, KVCC shall be provided with two (2) bound copies of operations & maintenance instructions for any equipment provided by contractor.

C.1.7 LABELING – CABLE, DROPS & PATCH PANELS

C.1.7.1 OVERVIEW

Every component of the telecommunications wiring system must be labeled. All cables must be labeled to show the source and destination at each end.

All labels must be easily viewed. All cables, components and device identifiers must be unique. All labels must be permanent and machine printed.

All cables shall be labeled with a wraparound self-laminating machine produced label. All cables shall be labeled at the faceplate and in the terminating distribution point. Labels shall be located not less than 4 inches from the jack at the faceplate and not more than 10 inches from the jack at the faceplate. Labels in the distribution point shall be located so that they can be easily read. Placement of the label should not exceed more than 6 inches from the jack.

All faceplates shall be individually labeled along with labels for each cable located behind the faceplate in accordance with KVCC labeling standards. All patch panels shall be individually labeled and each port on the patch panel labeled.

C.1.7.2 FACEPLATE - DATA

All jack faceplates should be labeled accordingly with termination point location, panel ID and panel jack number. Faceplate number order should be reasonable and follow around the perimeter in a clockwise fashion. Once a scheme has been established in a particular building, that scheme should be followed regardless of the situation. Keeping in mind that a building might only have one termination closet, doesn't rule out an additional termination closet being established some time later for future growth/building. Faceplates should be labeled like these examples:

CDF-XX-XX-A01
CDF-XX-XX-B24
BEF-XX-XX-A12

Labeling Components:

BEF-AF-01-A01

BEF-AF-01	designates the distribution frame
A	designates the patch panel
01	designates the port

Future cable installations regardless of jack location should be labeled with the patch panel information. For example in Building A room 101 jacks CDF-AF-02-A01, BEF-AF-01-A02 were installed during construction, however there is now a need for additional cabling. These cables should be labeled sequentially based on patch panel termination, in this example CDF-AF-01-D03 and BEF-AF-01-D04.

Legacy buildings & facilities will continue to use the MDF & IDF designations.

C.1.7.3 FACEPLATE - VOICE

All voice cabling installed since 2010 has used data cabling standards, termination points and jack locations. From that point forward all voice cabling will be referred to data cabling. Follow the data cabling plan in this document.

C.1.7.4 PATCH PANELS - DATA

The patch panel shall be clearly identified in sequential order, top to bottom, starting with the letter "A". The patch panel at the top left shall be labeled as patch panel letter "A". Patch panels beneath patch panel number one shall be labeled "B","C" etc. If multiple distribution racks are present in the Telecommunication Room, the patch panels adjacent to the leftmost rack (when facing the racks), rack #1, shall continue the sequential labeling beginning with the patch panel at the top and will continue.

The patch panel ports shall be labeled with 1-X depending on the number of ports on each panel.

C.1.7.5 VOICE PUNCH DOWN BLOCKS

Retrofitted voice punch down blocks should be 110 style modules. The punch down blocks shall be labeled sequentially starting with V-01, V-02 etc. New installations will be terminated in Cat6 patch panels. See specifications for data cabling

and termination.

C.1.7.6 LABELING SCHEME EXAMPLE

See section C.1.7.2 FACEPLATE - DATA

SECTION D: ENVIRONMENT & POWER

D.1 ENVIRONMENT AND POWER CONSIDERATIONS

D.1.1 HVAC

All telecommunication closets must maintain certain environmental conditions. Equip all telecommunications rooms to provide an appropriate atmosphere for active network equipment on a year round basis. HVAC equipment must operate 24/7/365 days of the year. Emergency power must be provided to the HVAC systems.

Temp. Range: 18 to 24 C (64 to 75 F) Humidity: 30 to 55% RH.

D.1.2 ELECTRICAL CIRCUITS

A minimum of two dedicated 20A, 110V AC duplex outlets, ideally from separate circuit breaker panels but at least each on separate circuits shall be provided for equipment power except where otherwise specified. Install, in all Telecommunication Rooms and Entrance Facilities. Receptacles should be evenly placed around the telecommunications room, eighteen inches (18") AFF (above finished floor), in accordance with NEC specifications and/or local fire codes.

D.1.3 ELECTRICAL GROUNDING & BONDING

Solid copper grounding busbars with insulated standoffs must be installed in all entrance facilities, equipment rooms and telecommunications rooms. All frames, cabinets and telecommunications equipment shall be grounded to the telecommunications grounding busbar (TGB) system.

A 1/4-inch X 4-inch X 20-inch or larger insulated copper telecommunications grounding busbar is to be bonded to building steel, or to an approved telecommunications main grounding busbar (TMGB) system, with #2 AWG copper wire in 3/4-inch PVC conduit in accordance with ANSI/TIA/EIA-607 (CSA T527) and J-STD-607-A.

The conduit system and neutral conductors of the wiring system shall be grounded in accordance with NEC. The grounding system shall be installed in a workmanlike manner and shall be inconspicuous. Continuity of the ground shall be maintained throughout the building. Continuity of equipment and raceway ground shall be insured by the use of double lock nuts and insulated grounding bushings bonded to enclosures in accordance with NEC Article 250-79 and Table 250-95 at service equipment at all panel boards, safety switches, pull boxes, etc. Convenience outlets shall be grounded by means of a bonding wire attached to the outlet box in a manner approved by NEC Article 250-114. All equipment or device grounds at panel boards, service or distribution equipment shall be connected to ground bars in such equipment with set screw connectors. All equipment and device feeders (receptacles, motor connections, etc.) shall include a green ground wire, sized as per NEC, to be run in conduit.

D.1.4 UPS & DIESEL GENERATORS

If emergency power is available, circuits should be connected, otherwise an approved Uninterruptible Power Supply that is capable of handling all of equipment load plus 50% for expansion is required.

SECTION E: APPLICABLE CODES & STANDARDS

E.1 OVERVIEW

Where applicable, all contractor-provided equipment shall be UL listed, FCC approved and registered, meet State and Federal fire codes, electrical codes and REA standards. All equipment furnished by the contractor shall be manufactured, assembled, installed and tested in accordance with the following current industry standards, and shall be considered minimum requirements:

1. The American National Standards Institute (ANSI)
2. The Institute of Electrical and Electronic Engineers (IEEE)
3. The National Electrical Manufacturer's Association (NEMA)
4. Insulated Power Cable Engineers Associates (IPCEA)
5. Occupational Safety Health Act (OSHA)
6. National Fire Protection Associations (NFPA)
7. The National Electrical Code (NEC)
8. The Telecommunications Industry Association (TIA)
9. The Electronics Industry Association (EIA)
10. International Organization for Standardization (ISO)
11. International Electrotechnical Commission (IEC)
12. National Fire Protection Association (NFPA)
13. Building Industry Consulting Service International (BICSI)
14. Underwriters' Laboratories (UL) (where applicable)

All work shall be accomplished in strict conformity with all laws and ordinances applying to the operation under this contract, including the latest regulations of all municipal and other public authorities having jurisdiction and state electrical codes. Installation shall also meet the standard requirements of NEC, OSHA and NFPA. The contractor will be held to complete all work necessary and to provide all equipment required to comply with the foregoing without extra compensation.

Unless otherwise stated within this document the following industry standards, codes and all of their addendums must be followed closely.

E.2 INDUSTRY STANDARDS AND CODES:

1. ANSI/TIA/EIA-568-A: The commercial building standard for telecommunications wiring.

2. ANSI/TIA/EIA-568-B: This standard specifies the component and transmission requirements for media

3. ANSI/TIA/EIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces.

4. ANSI/TIA/EIA-606-A: Administration Standard for Commercial Telecommunications Infrastructure.

5. ANSI/TIA/EIA-607-A: Commercial Building Grounding and Bonding Requirements for Telecommunications.

6. EIA/TIA TSB-36: Technical Systems Bulletin Additional Cable Specifications for Unshielded Twisted Pair Cables.

7. EIA/TIA TSB-40A: Telecommunications Systems Bulletin Additional Transmission Specifications for Unshielded Twisted-Pair Connecting Hardware.

8. ANSI/TIA/EIA-942: Telecommunications Infrastructure Standard for Data Centers.

9. ISO/IEC 11801: Generic cabling for customer premises.