Standards and Practices for Communications Environments

Information and Communications Technology Structured Cabling Standards

DC Office of the Chief Technology Officer

April 20, 2020

V1.4

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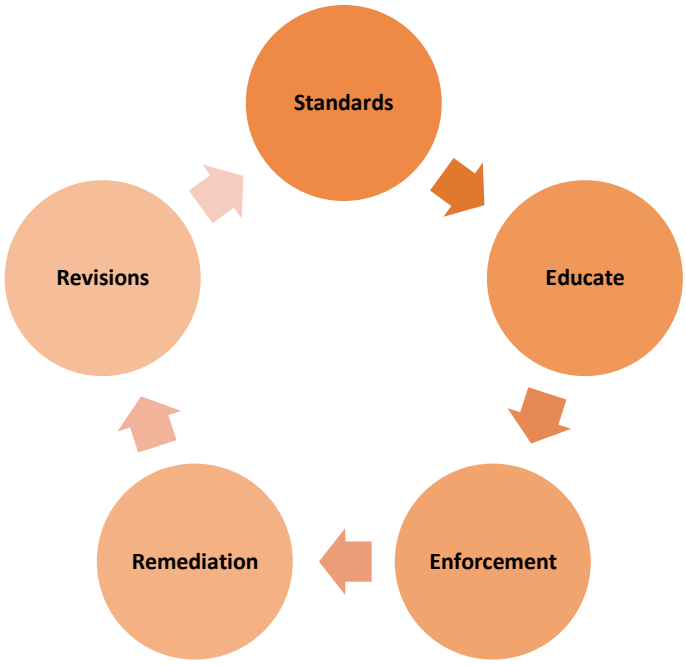
1 Introduction

This document provides guidelines and standards required for all design, installation, testing, modification, and removal of telecommunications cabling infrastructure in buildings where OCTO DC-Net services will be installed.

This guide is for anyone who will install, test, modify, or remove District government owned or operated communications infrastructure or who is responsible for overseeing these tasks, such as District government employees, telecommunications contractors, or 3rd party vendors. This document's purpose is to:

- Establish standards, codes, and industry best practices defined by each of the DC-Net functional teams within a single document.
- Educate our partner organizations including the Department of General Services (DGS), DC Public Schools (DCPS), and other entities responsible for overseeing the standards and best practices to provide consistent work product.
- Formalize the inspection process of our partner organizations' vendors and OCTO-managed vendors to improve compliance and resolve issues before work is complete.
- Coordinate remediation efforts with partner organizations for noncompliant infrastructure. Additionally, OCTO will work to remediate outstanding code and standards issues that have occurred before the initiative took shape.
- Reflect updates to ICT design and installation processes, standards, and work practices through annual updates to this document.



1.1 Document Revision History

Date	Version	Description	Author
07/01/2018	1.0	Update DC-Net Cabling Standards	J Burbridge, J Longenecker
07/27/2018	1.1	DC-Net internal team review comments incorporated, standards updated, firestopping updated, equipment room specifications updated	J Burbridge, J Longenecker, J Raye
12/18/2018	1.2	DC-Net internal team review comments – OSP, ISP. External stakeholder review.	J Burbridge, J Longenecker
6/14/2019	1.3	Revisions in Section 2.2.3. Added figure in Section 3.1. Updated Single-mode and Multi-mode fiber content in Section 5.2.2.	J Burbridge Bruce Jones
4/15/2020	1.4	Updated content throughout the document. Moved all product specifications to new Section 8 “Product Specifications and Requirements." Moved Firestopping information to new Section 9 “Firestopping.” Expanded Section 2.5 “Documents and Submittals and Section 3.6 “Labelling.”	J Burbridge OSP, ISP team inputs

1.2 Document Scope

A. This guide focuses solely on the design, installation, test, modification, and removal of District government owned or operated ICT infrastructure in buildings. It does NOT cover:
    a. Off-site services, including outside plant work in streets and on street poles.
    b. Building construction
    c. Provision of electrical wiring and outlets
    d. Provision of data concentrators, hubs, switches, servers, computers, and other active devices such as PBXs
    e. Painting
    f. Removal of asbestos, if required
    g. Plumbing
    h. Heating, ventilation, and air conditioning (HVAC)

2 Workmanship, Conduct, and Safety

This section explains the OCTO DC-Net requirements for ICT contractors. Contractors are expected to:

- Adhere to codes and standards.
- Use products per specifications and manufacturers' directions.
- Practice quality workmanship in methods and quality of work and conduct yourself professionally. Always be ready for inspection.
- Adhere to COVID-19 safety guidelines.
- Document work and communicate issues to OCTO.
- Meet OCTO-specific preferences.

2.1 Adhere to Codes and Standards

A. All work conducted in the OCTO/DC-Net ICT environment shall be designed and implemented to adhere to all federal, state, and local codes, rules, regulations, and ordinances governing the work, even if not specifically referenced in this document. All work and materials shall comply with:
   a. Local regulations in the DC Department of Consumer and Regulatory Affairs/DC Municipal Regulations (DCRA-DCMR).
   b. NESC and National Electrical Code (NEC-NFPA-70 2011Edition) requirements except where local codes and/or regulations are more stringent.
   c. Occupational Safety and Health Administration (OSHA) construction regulations and standards and other applicable safety rules.
   d. CSI MasterFormat Division 27.
   e. BICSI standards.
   f. Other applicable codes and standards. (For details, see "Codes and Standards" on page 77.)

B. Local zoning, IBC/ICC (Building Code), DCRA-DCMR, and NEC-NFPA-70 code requirements shall take precedence unless directed otherwise by local Authorities Having Jurisdiction (AHJs) within the District of Columbia.

C. All standards, code regulations, laws and any other special requirements deemed necessary by the local AHJ are subject to adoption/changing processes.

D. If two or more of the ICT industry standards, codes, or regulations in this document conflict, the more applicable, current, or strictest shall apply.

E. Upon notification in writing from OCTO regarding an industry standard or code violation, the Contractor has 30 days to bring all violations into compliance with applicable ICT industry standards, codes, regulations and any other requirements deemed necessary by the AHJ.

2.2 Use Quality Materials

2.2.1 Materials Standards

Contractors shall:

A. Ensure that equipment and materials, unless otherwise noted, are new, conform to grade, quality, and standards specified, and are produced by manufacturers regularly engaged in the manufacture of these products. Ensure that materials conform to applicable requirements listed in "Product Specifications and Requirements" on page 60 and "Codes and Standards" on page 77.
B. Use equipment and materials that have and are labeled with industry certification, labels, or standards.
C. Ensure that the equipment and materials specified are based on acceptable manufacturers listed in the contract. Submit any deviation from agreed-upon materials to OCTO for evaluation and approval before use.
D. When using products—including equipment, assemblies, parts, and components—of more than one approved manufacturer, ensure these are identical in function and of comparable quality.
E. Use materials determined safe by a nationally recognized testing organization, such as Underwriters' Laboratories, Inc. (UL), or Factory Mutual Engineering Corporation. Materials shall be labeled, certified, or listed by such organizations. Where third party certification is required for packaged equipment, the equipment shall bear the appropriate certification label.
F. Ensure all work complies with the requirements and recommendations of product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
G. For custom-made equipment or related installations constructed for a project, ensure manufacturer certification of safety based on test data.
H. For custom-made fabrications, carefully consider safety, technical, functional, and aesthetic aspects of equipment and its installation as well as potential impact to warranty and servicing agreements before deciding to fabricate. Submit proposed custom-made fabrications to OCTO for evaluation and approval before use.

2.2.2 Warranty

Contractors shall:

A. Provide a full warranty against defects in materials and workmanship for at least one (1) year following the date of completion as agreed upon with OCTO. The warranty period does not include temporary operation of the equipment for temporary conditioning, testing, etc., prior to occupancy.
B. Transfer manufacturer's warranties and General System Guarantee to the property manager. Submit these warranties on each item with drawings. Detail specific parts

within equipment that are subject to separate conditional warranty. Warranty proprietary equipment and systems involved in the contract during the guarantee period.

C. Replace or substitute equipment as per your agreement with OCTO and/or the property manager. Typically, this is within 24-72 hours of first notification from OCTO. If you cannot complete repairs during this time, forward documentation of progress to OCTO and the property manager every 72 hours.
D. Replace or repair any defective equipment, materials or workmanship, including damage to the work provided under other divisions of this contract, at no extra cost to the property manager for the duration of the stipulated guarantee periods.

2.2.3 Delivery, Storage, and Handling

Contractors shall:

A. Protect equipment during transit, storage, and handling to prevent damage, theft, soiling, and misalignment.
B. Store on-site equipment and materials securely in areas as directed by the property manager.
C. Coordinate with the property manager on delivery, unloading, setting in place, fastening to walls, floors, ceilings, or other structures where required, interconnecting wiring of system components, equipment alignment and adjustment, and other related work if expressly defined.
D. Store equipment only where conditions within manufacturer's recommendations for environmental conditions.
E. Install only properly function, undamaged equipment. Remove damaged equipment from site and replace with new equipment.
F. Be responsible for safekeeping your own and subcontractors' property, such as equipment and materials, on the job site. Neither OCTO nor the property manager assumes responsibility for protection of above-named property against fire, theft, and environmental conditions.
G. Store and handle firestopping materials appropriately. See "Firestopping" on page 55.

2.3 Quality Assurance

Contractors shall:

A. Be established communications and electronics contractor with at least three (3) years of experience, licensed and bonded to work in the District of Columbia.
B. Be certified, trained, and authorized to install the required equipment and cabling.
C. Ensure subcontractor work follows same standards to which Contractor is accountable.
D. Employ a current RCDD® (Registered Communications Distribution Designer) responsible for quality control during installation, equipment set-up, and testing.

E. Have 30 percent or more BICSI Registered Telecommunications Installers.
F. Installation personnel meet manufacturer's training and education requirements for implementation of extended warranty program.
G. Perform all work in a professional and workmanlike manner. All construction methods not specified in the Contract Documents shall be subject to the control of OCTO.

2.4 General Work Practices

Contractors shall adhere to the following general work practices.

2.4.1 Sequence and Scheduling

A. Submit to OCTO/DC-Net the schedule for installation of equipment and cabling. Indicate delivery, installation, and testing for conformance to job completion dates. Provide dates for bid award, installation start date, completion of station cabling, completion of riser cabling, completion of testing and labeling, cutover, completion of the final punch list, start of demolition, property manager acceptance, and demolition completion.

2.4.2 Use of Site, Protection of Facilities, and Continuity of Service

A. Follow the property manager’s direction on use of the site and access to where work will be performed.
B. Protect the property manager’s facilities, equipment, and materials from dust, dirt, and damage during construction.
C. Coordinate with the property manager to minimize conflict and facilitate the property manager’s normal business operations. Avoid interfering with the ordinary use of streets, aisles, passages, exits, and operations of the property manager. Arrange work to minimize shutdown time.
D. Schedule necessary shutdowns of plant services with the property manager and obtain written permission from the property manager. Provide at least three (3) days’ notice for any systems shutdown. Property manager’s personnel will perform shutdown.
E. If services are inadvertently interrupted, immediately furnish labor (including overtime, material, and equipment necessary) for prompt restoration of interrupted service.
F. Replace and/or repair to original or better condition, at no additional cost to the property owner, any existing structures, materials, equipment, etc. inadvertently damaged during construction.
G. Accept sole responsibility for the safety of the public and workers per all applicable rules, regulations, building codes and ordinances.
H. Remove protection at completion of the work.
I. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged during construction at no additional cost to OCTO.
J. Remove all surplus material and debris from job site and dispose of them legally.

2.4.3 Pre-Installation Site Survey

A. Prior to starting systems installation, meet at the project site to coordinate efforts with the property manager's representative and representatives of trades performing related work. Review areas of potential interference and resolve conflicts before proceeding with the work. Facilitate with the General Contractor to schedule completion of the equipment room and telecommunications rooms.
B. Examine areas and conditions under which the system is to be installed. Do not proceed until you achieve satisfactory conditions.

2.4.4 Installation

A. Receive, check, unload, handle, store, and protect equipment and materials to be installed as part of the contract per "Delivery, Storage, and Handling" on page 9.
B. Install materials and equipment per applicable standards, codes, requirements, and recommendations of national, state, and local AHJs, and National Electrical Code® per "Codes and Standards" on page 77.
C. For cable installation, adhere to manufacturer's published specifications for pulling tension, minimum bend radii, and sidewall pressure.
D. Installation shall:
    a. Use approved wire, cable, and wiring devices.
    b. Perform neat and uncluttered wire termination.

2.5 Documentation and Submittals

2.5.1 Documentation and Drawings

OCTO requires Contractors provide documentation and submittals that include drawings showing planned changes ("red line") and outcome ("as built"), product documentation, testing reports, and so on.

A. Before initiating work, provide drawings and documentation showing current ICT infrastructures, pathways, spaces, and environments, identifying planned changes (red line) and distribute these to OCTO and other stakeholders.
B. Upon completing work, revise drawings to show changes (as built) and distribute these to OCTO and other stakeholders.
C. Submit all documentation per accepted trade practices. (See CSI MasterFormat Division 27 Communications.)
D. Provide documents and drawings in commonly shared formats such as, Microsoft Word, Adobe PDF, Visio, Auto CAD, etc.
E. Alert OCTO immediately in writing if any drawings or specifications may result in ICT industry standards, norms, and code violations if constructed.

Table 1: Required Documentation and Submittals

Work Area	Required Submittals
Work Schedule	**Due before construction:** a) Schedule all equipment and cabling installation. Indicate delivery, installation, and testing to conform to specific job completion dates. Provide dates for bid award, installation start date, station cabling completion, riser cabling completion, testing and labeling completion, cutover, final punch list completion, start of demolition, property manager acceptance, and demolition completion.
Firestopping	a) **Product Data:** Provide manufacturer's standard catalog data for specified products showing compliance with referenced standards and listing numbers of systems in which each product is to be used. b) **Schedule of UL/ASTM System Drawings for Fire Rated Construction:** Submit schedule of all expected opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings. c) **UL/ASTM System Drawings for Fire Rated Construction:** Furnish copies of all UL/ASTM Systems identified in schedule. Include any engineering recommendations. d) **Certificates:** Provide product Certificate of Compliance from the manufacturer certifying material compliance with applicable code and performance characteristics. e) **Installation Instructions:** Submit manufacturer's printed installation instructions.
Grounding and bonding	**Due before construction:** a) Product information 1. Manufacturer's product information cutsheet or specifications sheet with the specific product number identified. 2. Make all OCTO ICT bonding infrastructure connections with appropriate listed bonding hardware and applications by contractors, government agency personnel and responsible parties. a) Shop drawings 1. Scaled drawings (floor plans not less than 1/16" = 1'-0") indicating the location and size, dimensions, type of connection (e.g., mechanical, exothermic weld of each bonding busbar (e.g., TMGB/PBB, TGB/SBB), conductor (e.g., BCT, GE, TBB), connections (e.g., lugs), and splice points. 2. Scaled plan and elevation drawings of TRs (not less than 1/4" = 1'-0") indicating locations of busbars (e.g., TMGB-PBB, TGB-SBB, UBC, RGB-RBB). 3. Provide separate bonding and grounding ICT infrastructure drawings. **Due after construction**: a) Record drawings 1. Scaled drawings (floor plans not less than 1/16" = 1'-0") indicating actual location and size/length of TMGB-PBB, TGBs-SBBs, BCT-BTC, GE and TBB conductors and all splice points. 2. Scaled plan and elevation drawings of TRs (not less than 1/4" = 1'-0") indicating actual locations of TMGB-PBB and TGBs-SBBs. 3. Provide separate bonding and grounding ICT infrastructure drawings. b) Manufacturer specification sheets (cutsheets) and installation instructions/manuals for all installed products. c) A letter from the contractor project RCDD stating that the ICT Bonding-Grounding system was installed per project documents and referenced codes, standards (best practices), and guidelines. This letter also acknowledges that the ICT bonding-grounding system has been fully tested per these specifications.

Cable trays	**Due before construction:** a) Provide submittal information for evaluation before materials are delivered to the site. Provide product data submittals for all products at the same time. b) Submit a letter stating that materials will be provided as indicated; list any items that will not be provided as indicated. State in the letter that the Contractor has reviewed the indicated items and understands they apply to all aspect of the project. c) For items noted as "Or Equal" and not provided as specifically named, submit standard cut sheets or other descriptive information along with a separate written description detailing reason(s) for the substitution. d) Provide standard manufacturer's cut sheets and Operating and Maintenance (O&M) instructions at the time of submittal review for each device in the system. These instructions shall detail how to install and service the equipment and include information necessary for rough-in and prepare the building facilities to receive the materials. **Due after construction:** a) Submit an O&M manual to the OCTO/DC-Net Project Manager, reflecting any changes that occurred during construction. b) Maintain at the project site at least one set of drawings, specifications, and addenda. Drawings shall consist of red line markups, specifications, and spreadsheets. 1. Document changes to the system from schematics shown in contract documents, and clearly identify component labels and identifiers on drawings. 2. Keep drawings at the job site and make available at all times to OCTO. 3. Keep drawings current throughout the progress of construction. ("Current" is not more than one (1) week behind actual construction.) 4. Show identifiers for major infrastructure components on drawings. Get all ICT infrastructure change orders pre-approved by OCTO or designated government personnel before performing work.
Surge protection	Note in drawings type and location of protection devices and all wiring information.
All Backbone and Horizontal Cabling	a) Provide product data sheets and samples for all products, including: 1. All listed ICT-SCS distribution cabling and wiring 2. All listed ICT-SCS cross-connecting and patching cables 3. All listed connectors and required tools 4. All termination system components for each cable type 5. All ER and TR listed ICT-SCS horizontal cable management 6. All listed ICT grounding-bonding infrastructure components 7. All listed firestop systems (including manufacturer published installation requirements to include listed requirements of firestopping assemblies, wall-floor membrane penetrations; F 'Hourly Rating', T, L, W and S-Ratings, if applicable) 8. All listed ICT-SCS cable raceway and supporting hardware 9. Other apparatus required for a complete and functional system b) Shop drawings c) Project closeout test data: 1. Submit complete end-to-end test results and loss budget calculations to OCTO in electronic format and hard copy. Handwritten test results will be rejected. If special software or license is required to review test data electronically, provide a copy of the software and license with the test data. 2. Test data shall reflect the OCTO labeling scheme. 3. Attach a sample Test Instrument Data Sheet. 4. Attach a sample Reference Power Measurement Form. a) As-built documentation

	b) Warranty c) Distance between terminations in the entrance facility, Equipment Room/main cross-connect-MC/BD/CD, horizontal cross connect-HC/IC/IDF or floor distributor-FD/TR.
Wireless Access Points	Provide wireless AP installation document that includes floor plan, WAP locations, and exact label information.
Project closeout report	Provide project closeout report after construction and include: a) Installation company name, contact information, project manager and installation supervisor name. b) Project scope including project start and end dates, building name and address, floors where installation work was completed. c) Project summary including number of work areas or equipment cabinets/racks cabled, total number of drops and type of cabling system installed. List the types of backbone cabling installed, number of backbone space locations, and number of connections terminated. List any special or unique information regarding site conditions. d) Fiber optic loss test data and OTDR test data including, at a minimum, test identification, pass/fail, test parameter title, test data and test time. e) 4-pair cable testing data including, at a minimum, test identification, cable length, pass/fail, test parameter title, test data and test time. f) Installation Contractor Warranty. g) Structured Cabling Manufactures Warranty. h) As-built drawings showing cable placement pathways and termination spaces (work areas, TRs, ERs, entrance facilities, etc.). i) Elevation and plan view drawings for cabinet and rack elevations. j) Floor plan markups showing outlet locations, type, and cable marking of cables.

2.5.2 Permits, Fees, and Certificates of Approval

The Contractor shall:

A. Coordinate permitting, fees, and certificates of approval with the property manager.
B. Keep copies of permits and certificates on hand throughout the period of performance.

3 Common Work for Communications Systems

Content in this section follows the CSI MasterFormat Division 270500. It includes the following:

- Network facilities overview
- Grounding and bonding for ICT infrastructure

See also:

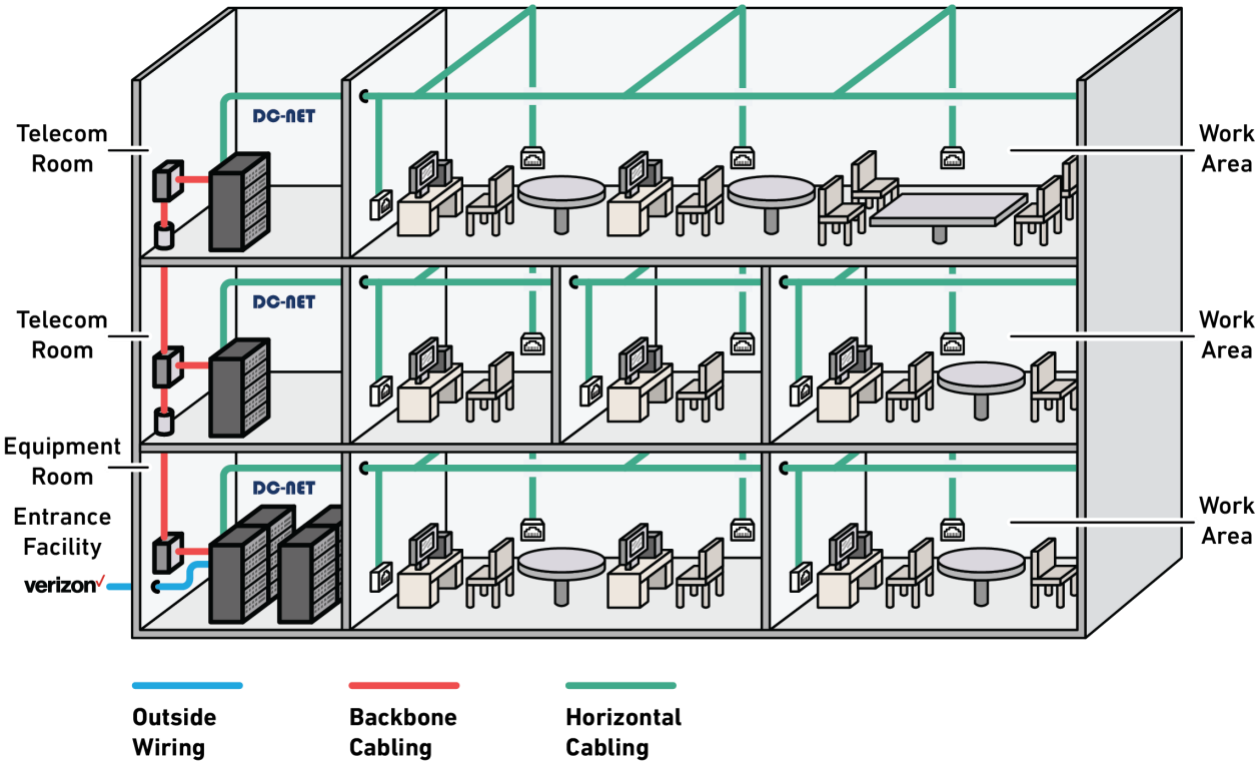
- “Labeling“ on page 32.
- “Firestopping” on page 55.
- “Product Specifications and Requirements” on page 60.

3.1 Network Facilities

A telecommunications cabling system generally consists of one telecommunications outlet (TO) per workstation, wall telephones in common and mechanical areas, wireless access points (WAPs), telecommunications rooms (TRs) and telecommunications enclosures (TEs) on each floor, and the equipment room (ER) commonly in the building basement at the point of entry for telecommunications cables, or entrance facility (EF). The demarcation point (DP) is the point of entry for provider Outside Plant (OSP) cable to the ER rack/cabinet termination – typically at a panel or switch. In the OCTO ICT environment DC-Net manages the ER and TRs.

The carrier conduit terminating at the EF, in which DC-Net fiber is placed, is typically Verizon. Vertical backbone fiber and copper cabling extends from the ER to each floor TR or TE. Horizontal cabling, typically copper only, extends from the TR or TE on each floor to TOs and WAPs on that same floor. (See Figure 1.)

Figure 1: Telecommunications Cabling Infrastructure – DC-Net



3.2 Grounding and Bonding

3.2.1 General

Contractors shall:

A. Provide all materials and labor for installing a permanent, code-compliant grounding and bonding system for the ICT infrastructure, including all communications circuits, raceways, ladder rack and cable trays. Work shall include materials, equipment and apparatus not explicitly stated or noted in Contract Documents but required for the system.
B. Perform grounding and bonding in compliance with Uniform Building Code, Uniform Fire Code, and ANSI-TIA #607-D Best Practices and NEC-NFPA-70 code requirements and follow CSI MasterFormat Division 270526. For more information, see “Codes and Standards” on page 77.
C. Perform all grounding connections by a licensed electrician in good standing with the District of Columbia per DCRA-DCMR code requirements.
D. Use only approved connections and position these in accessible locations. Connect the grounding conductor to the grounding electrode via exothermic weld, listed lugs, listed pressure connectors, listed clamps or other approved listed alternatives.
E. For labeling requirements, see “Labeling“ on page 32.

F. For firestopping requirements, see “Firestopping” on page 55.

3.2.2 Execution

3.2.2.1 INSTALLATION

A. Do not bond to water pipes, due to plastic fittings and other non-conductive hardware associated with this type of bonding/grounding application/connection, unless required to do so by the NEC.
    a. Coordinate installation of the grounding and bonding system with the electrical power distribution’s grounding infrastructure.
B. Grounding/Bonding:
    a. Primary Busbar (PBB): Provide a minimum of one PBB per Entrance Facility for each building as shown on Contract Documents. Install PBB(s) and directly bond PBB(s) to electrical service ground and to related TBB(s).
    b. Secondary Busbar (SBB): Provide a minimum of one SBB per TR in line with applicable standards (see “Codes and Standards” on page 77). Directly bond each SBB to its related TBB and to the nearest building structural steel or other permanent metallic system. Use Electrical Distribution Panels is another source for general equalization or bonding of SBBs.
    c. TBB: Provide TBB(s) as shown on Contract Documents and as required to bond all non-current carrying metal telecommunications equipment and materials to the nearest SBB. Use TBB(s) to connect the PBB to each of the SBB(s). Route along the shortest and straightest path with minimum bends. All bends shall be sweeping. TBB(s) shall be continuous (without splices). Ensure that all bonding breaks through paint to bare metallic surface of all painted metallic hardware.
    d. Bond metallic raceway (including cable tray) together and to the nearest SBB. Ensure that bonding breaks through paint to bare metallic surface of painted metallic hardware.
    e. Provide cable tray splices per manufacturer requirements to create a continuous bonding conductor throughout the entire cable tray.
    f. Bonding conductors:
        i. Bond distribution conduits to cable tray.
        ii. Provide bonding jumpers at expansion joints, sleeves and any other locations where electrical continuity is interrupted.
        iii. Provide bonding conductor between cable tray and the electrical power distribution system grounding infrastructure.
C. Where the manufacturer does not provide bending radii information, minimum-bending radius shall be 15 times cable diameter. Arrange and mount equipment and materials in a manner acceptable to the engineer and property manager. Penetrations through floor and fire-rated walls shall utilize intermediate metallic conduit (IMC) or galvanized rigid conduit (GRC) sleeves and shall be firestopped after installation and testing, utilizing a

firestopping assembly approved for that application. If STI EZ-Paths are used, firestopping does not apply. Install station cabling to the nearest TR, unless otherwise noted.

Figure 2 shows a typical Entrance Facility (EF) coming into a building. PBB should be bonded to the main building facility ground busbar, ACEG or via BTC going back to GEC/GE located outside. Figures 3-5 show examples of grounding and bonding in the EF, Equipment Room, and Telecommunications Room.

Figure 2: Grounding and Bonding – Small System Example

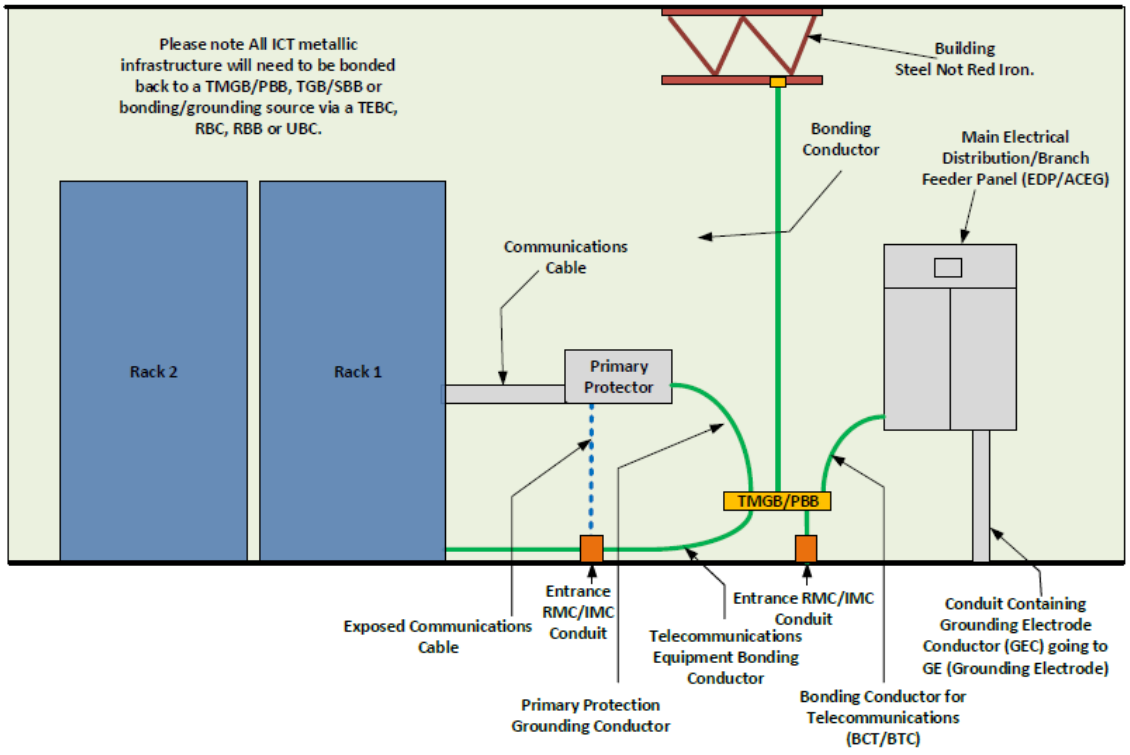


Figure 3: Grounding and Bonding at the Service Entrance

Figure 4: Grounding and Bonding in IT Equipment Room (from BICSI)

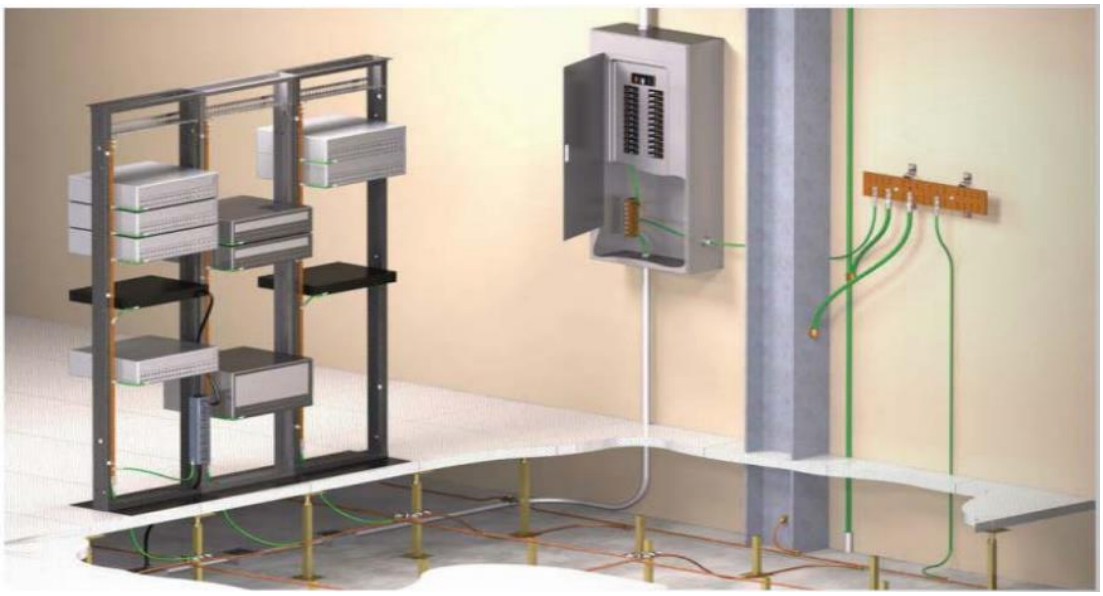
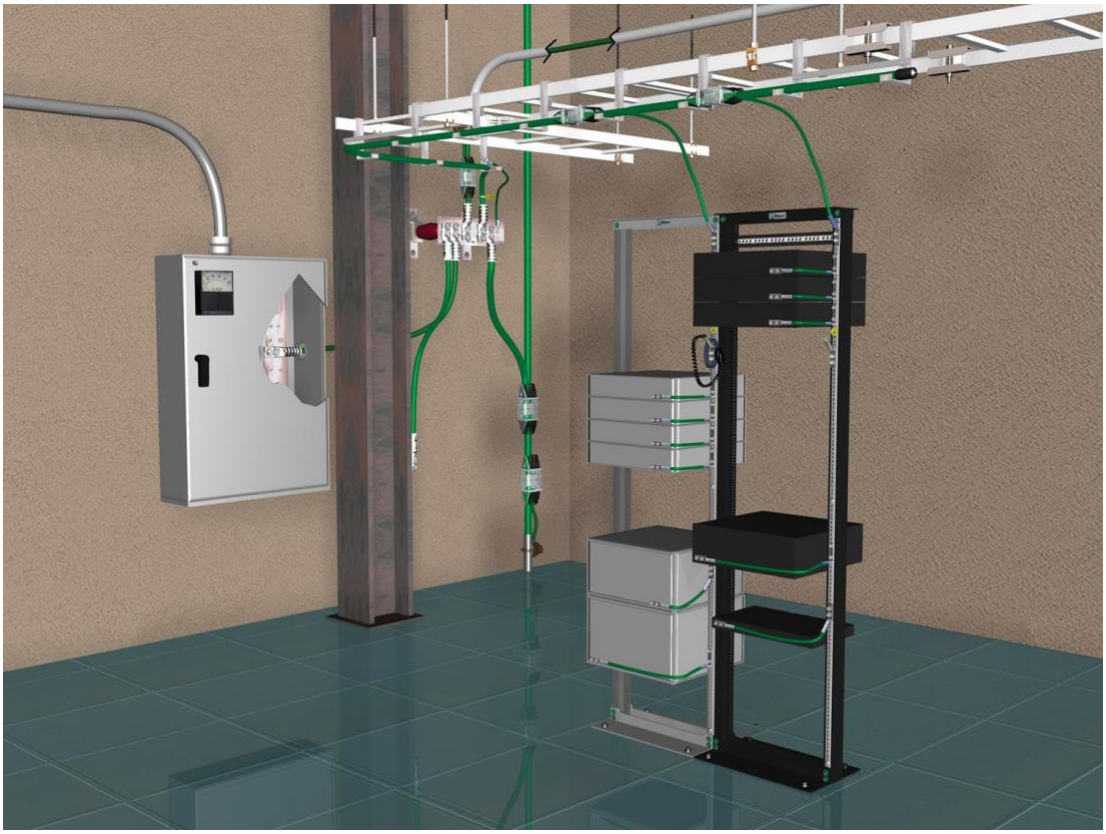


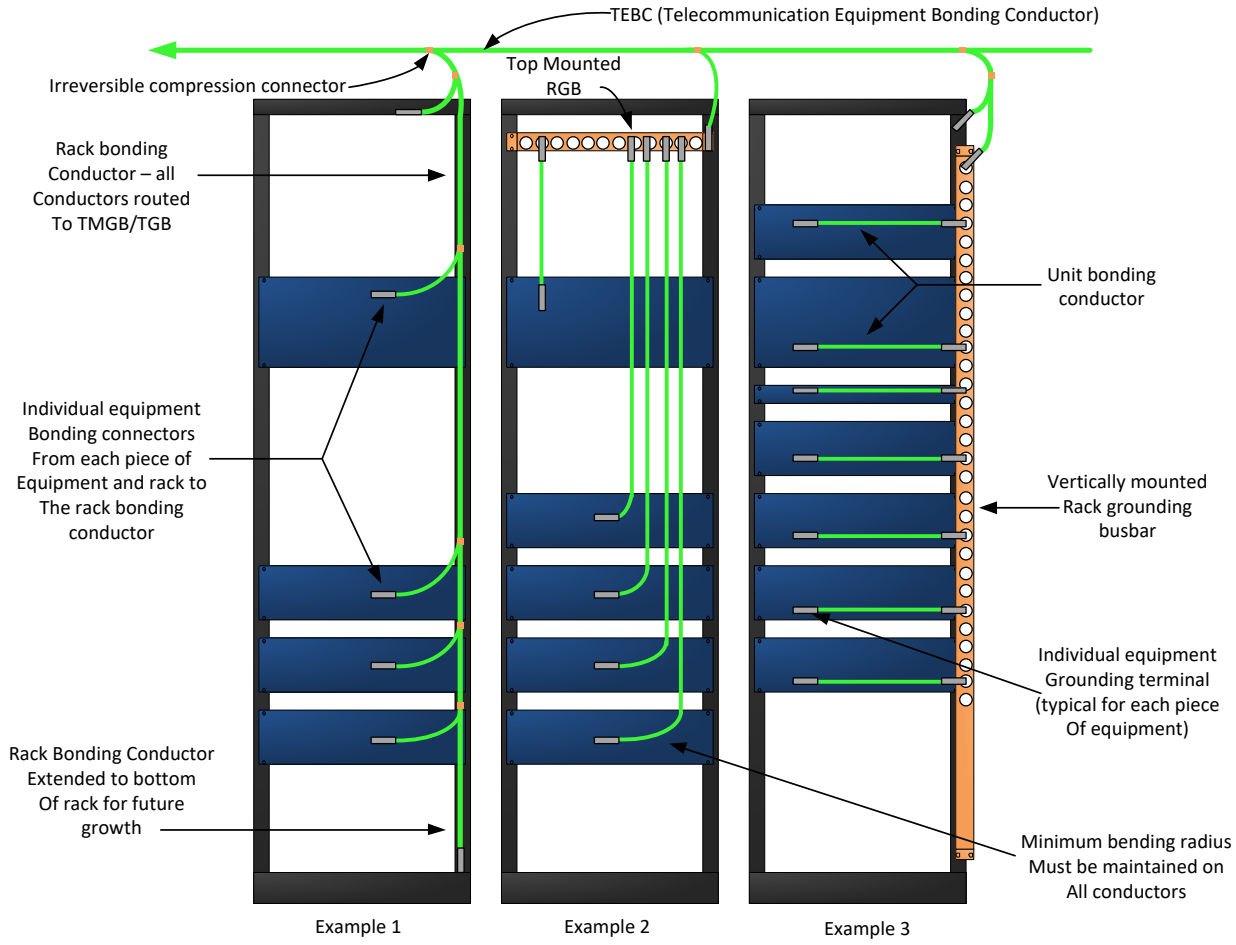
Figure 5: Grounding and Bonding in Telecommunications Room



3.2.2.2 EQUIPMENT RACKS

Use the following figure as a guide for grounding and bonding OCTO equipment racks.

Figure 6: Grounding and Bonding OCTO Equipment Racks (from BICSI)



Source: https://www.bicsi.org/docs/default-source/conference-presentations/2017-mea-uae/grounding-and-bonding.pdf?sfvrsn=3112558d_2

3.3 Hangers and Supports

A. Support structures are required for the installation of telecommunications cable, connecting hardware, and associated apparatus. These structures comprise components such as equipment racks, cabinets, distribution rings, hangers, J Hooks, plywood backboard, cable trays, conduits, slots, sleeves, and their associated hardware.
B. Work shall comply with ANSI-TIA #568-E.0-E.5, #569-D, BICSI TDMM 14th Edition and ITSIMM 7th Edition Publications Best Practices and follow CSI MasterFormat Division 270526.
C. When installing pathways, ensure that the pathway route is clear of obstructions such as HVAC ducts, large pipes, and structural beams within the building. When fire barriers are penetrated, firestop all penetrations to maintain the fire rated barrier.

3.4 Conduits and Pullboxes

3.4.1 General

A. Furnish, install, and place into adequate and successful operation *all* materials, devices, and essential accessories to deliver a complete code-compliant conduit, raceway system. Work shall include materials, equipment and apparatus not explicitly stated or noted in Contract Documents but required for the system.
B. Conduit, raceway system installation shall comply with ANSI-TIA #568-E.0-E.5, #569-D, TDMM 14th Edition and ITSIMM 7th Edition Publications Best Practices and follow CSI MasterFormat Division 270533. For more information, see “Codes and Standards” on page 77. Related CSI MasterFormat Sections:
    a. Division 26 Section: “Basic Electrical Materials and Methods” (NEC-NFPA-70 2011 Edition/DCRA-DCMR Article #12-C Code Requirements)
    b. Division 27 Section: “Grounding and Bonding for Communications Systems” (ANSI-TIA #607-D Best Practices and NEC-NFPA-70 Code Requirements)
    c. Division 27 Section: “Inside Plant Communications Systems” (ANSI-TIA #568-E.0-E.5, #569-E, NEC-NFPA-70, IEEE #802.3/#802.11, BICSI TDMM 14th Edition and ITSIMM 7th Edition Publications Best Practices)
C. Follow good workmanship practices per “General Work Practices” on page 10.
D. For labeling details, see “Labeling“ on page 32.
E. For firestopping requirements, see “Firestopping” on page 55.
F. For conduit and pullbox specifications, see “Product Specifications and Requirements” on page 60.

3.4.2 Execution

3.4.2.1 EXAMINATION

A. Examine surfaces and spaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until insufficient conditions have been amended.

3.4.2.2 INSTALLATION

3.4.2.2.1 General

A. Install raceways, boxes, enclosures, and cabinets as indicated, per manufacturer’s instructions. Provide a raceway for each location indicated. Do not gang raceway into wireways, pullboxes, junction boxes, etc., without explicit approval from OCTO/DC-Net.

3.4.2.2.2 Conduit

A. Install Electrical Magnetic Tubing (EMT) unless other conduit is shown in the Contract Documents or required by code.
B. Install conduit as a complete, continuous system without wires, mechanically secured and electrically connected to metal boxes, fittings and equipment. Blank-off unused openings using factory-made knockout seals.
C. Run conduit in the most direct route possible, parallel to building lines. Do not route conduit through areas in which flammable material may be stored.
D. Keep conduit at least 6” from parallel runs of flues and steam or hot-water pipes or other heat sources operating at temperatures above 100 degrees Fahrenheit. Install horizontal conduit runs above water piping.
E. Keep conduit away from sources of electromagnetic interface:
    a. 5” from fluorescent lighting.
    b. 12” from conduit and cables used for electrical power distribution.
    c. 48” from motors and/or transformers.
F. Do not exceed 295 feet total length for a given conduit run to be used for distribution cabling (from outlet box to telecommunications room), including intermediate conduits and junction boxes.
G. Install conduit exposed, except in finished areas or unless shown otherwise on the drawings. Do not install conduit below grade/slab unless specifically shown on Contract Documents as being installed below grade/slab.
H. Install exposed conduit in lines parallel or perpendicular to building lines or structural members except where the structure is not level. Follow the surface contours as much as practical. Do not install crossovers or offsets that can be avoided by installing the conduit in a different sequence or a uniform line.
    a. Run parallel or banked conduits together, on common supports where practical.
    b. Make bends in parallel or banked runs from same centerline to make bends parallel.
I. Conduits concealed above ceilings, furred spaces, etc., which are normally inaccessible may be run at angles not parallel to the building lines.
J. Wherever practical, route conduit with adjacent ductwork or piping and support on common racks. Base required strength of racks, hangers, and anchors on combined weights of conduit and piping.
K. Where conduits cross building expansion joints, use suitable sliding or offsetting expansion fittings. Unless specifically approved for bonding, use a suitable bonding jumper.
L. Support conduits:
    a. Provide anchors, hangers, supports, clamps, etc. to support conduits from the structures in or on which they are installed. Do not space supports farther apart than five feet.
    b. Provide enough clearance to allow conduit to be added to racks, hangers, etc. in the future.

c. Support conduit within 3 feet of each outlet box, junction box, gutter, panel, fitting, etc.

M. Ream conduits to eliminate sharp edges and terminate with metallic insulated grounded throat bushings. Seal each conduit after installation (until cable is installed) with a removable mechanical-type seal to keep conduits clean, dry and prevent foreign matter from entering conduits.

N. Install a pull string in each conduit.

O. For conduits entering through the floor of a telecommunications room, terminate conduits 6" above the finished floor.

P. Do not install communications conduits in wet, hazardous or corrosive locations.

Q. Where conduit is shown embedded in masonry, embed conduit in the hollow core of the masonry. Horizontal runs in the joint between masonry units are not permitted.

R. Where conduit is shown embedded in concrete, embed conduit a minimum of two inches from the exterior of the concrete. Do not place conduit in concrete less than four inches thick.
   a. Use 1" trade size conduit. Conduits sized smaller than 1" trade size conduit are not permitted embedded in concrete without approval from the Owner.
   b. Run conduit parallel to main reinforcement.
   c. Conduit crossovers in concrete are not permitted.

S. Where conduit exits from grade or concrete, provide a rigid steel elbow and adapter.

T. Where conduit enters a space through the floor and terminates in that space, terminate the conduit at 6" above the finished floor.

U. Where conduits terminate at a cable tray, the conduits shall be consistently terminated no more than 8" from the cable tray and have a visually uniform appearance.

V. Where several circuits follow a common route, stagger pullboxes or fittings.

W. Where several circuits are shown grouped in one box, individually fireproof each conduit.

X. Bend and offset metal conduit with standard factory sweeps or conduit fittings. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
   a. Conduit sweeps:
      i. Sweeps shall exceed 90 degrees.
      ii. Do not exceed 180 degrees for the sum of conduit sweeps for a section of conduit (between conduit termination points).
      iii. Sweep radius shall be at least 10 times the internal diameter of the conduit.
      iv. 90-degree condulets (LB's) and electrical elbows are not acceptable.
   b. Factory-manufactured sweeps are required for bends in conduit larger than 1¼" trade size.
   c. For bends in 1¼" trade size conduit and larger, field-manufactured bends (using a hydraulic bender with a 1¼" boot) are permitted only when factory-manufactured sweeps are not suitable for the conditions. In all other cases, factory-manufactured sweeps are required. "Hickey-bender" use is prohibited.

Y. Connect conduit to enclosures, cabinets, and boxes with double locknuts and insulating type bushings. Use grounding type bushings where connecting to concentric or eccentric knockouts. Make conduit connections to enclosures at the nearest practicable point of entry to the enclosure area where the devices are located to which the circuits contained in the conduit will connect.

Z. Penetrations for raceways:
   a. Do not bore holes in floor and ceiling joists outside center third of member depth or within two feet of bearing points. Holes shall be 1¼" diameter maximum.
   b. Penetrate finished walls and finished surfaces with a PVC or sheet metal sleeve with an interior diameter (ID) at least ¼" greater than the outer diameter (OD) of the conduit, set flush with walls, pack with fiberglass, seal with silicone sealant.
   c. Penetrate poured-in-place walls and free slabs with a cast iron sleeve (or Schedule 40 PVC black pipe sleeve for above-grade only) with retaining ring or washer. Set sleeves flush with forms or edges of slab. Pack around conduit with fiberglass and seal with silicone sealant.

AA. Raceway terminations and connections:
   a. Join conduits with fittings designed and approved for this purpose and make joints tight. Do not use set indent-type or screw-type couplings.
   b. Make threaded connections waterproof and rustproof by applying a watertight, conductive thread compound. Clean threads of cutting oil before applying thread compound.
   c. Make conduit terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
   d. Cut ends of conduit square using a hand saw, power saw, or pipe cutter. Ream cut ends to remove burrs and sharp ends. Where conduit threads are cut in the field, cut threads to have same effective length, same thread dimensions and same taper as specified for factory-cut threads.
   e. Provide double locknuts and insulating bushings at conduit connections to boxes and cabinets. Align raceways to enter squarely and install locknuts with dished part against the box. Use grounding type bushings where connecting to concentric or eccentric knockouts.
   f. Where conduits are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple, so no threads are exposed.

BB. Install conduit sealing fittings per manufacturer's instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed conduits, install each fitting in a flush steel box with a blank cover plate having a finish like that of adjacent plates or surfaces. Install raceway sealing fittings:
   a. Where conduits pass from warm to cold locations, such as the boundaries of air conditioned or refrigerated spaces and where conduits enter or exit buildings from outdoor areas, including underground ducts or conduit runs.

b. Where otherwise required by the NEC.

CC. Conduits shall be clean and dry.

3.4.2.2.3 Sleeves

1. Provide sleeves where required, sized as noted on Contract Documents. Where not noted, sleeve sizing shall be determined by the type and quantity of cable to be routed through the sleeve per ANSI/TIA-569-E cable capacity standards, plus an additional 20% for future expansion.
2. Provide core drilling where required for installation.
3. Seal between sleeve and wall or floor in which the sleeve is installed. Firestop all penetrations to restore wall or floor to pre-penetration fire-rating.

3.4.2.2.4 Surface Raceway

1. Provide surface raceway for all surface mounted telecommunications outlet boxes and as shown on Contract Documents.
2. Route surface raceway parallel to and perpendicular to surfaces or exposed structural members and follow surface contours.
3. Match surface raceway color as closely as possible the existing wall finish. Do not paint the surface raceway.
4. Install surface raceway systems completely, including insulating bushings and inserts as required by manufacturer's installation requirements. Close unused openings in the surface raceway using manufactured fittings.
5. Maintain a minimum 2" radius control at all bend points in the surface raceway.
6. Securely support the surface raceway by screws or other anchor-type devices at intervals not exceeding 10 feet and with no less than two supports per straight raceway section, per manufacturer's requirements. Tape and glue are not acceptable.
7. Mechanically and electrically continuous surface raceway shall be bonded and grounded to the grounding system.

3.4.2.2.5 Outlet Boxes

1. Provide outlet boxes and covers as shown on the Contract Documents and as needed. Verify that the appropriate cover type and depth is provided for each type of wall and finish. Provide extension rings as needed.
2. Coordinate box locations with building surfaces and finishes to avoid bridging wainscots, joints, finish changes, etc.
3. Install boxes in dry locations (not wet, corrosive, or hazardous).
4. Attach boxes securely to building structure with a minimum of two fasteners. Provide attachments to withstand a force of 100 lbs. minimum, applied vertically or horizontally.
5. Install boxes at the following heights to the bottom of the box, except where noted otherwise:
    a. Wall mounted telephones: 48" above finished floor.
    b. Workstation outlets: 18" above finished floor.

   c. Place boxes for outlets on cabinets, countertops, shelves, and similar boxes located above countertops two inches above the finished surface or two inches above the back splash. Coordinate and verify size, style, and location with the supplier or installer of these items prior to outlet box installation.
6. Recessed mounted outlet boxes:
   a. Recess boxes in the wall, floor, and ceiling surfaces in finished areas. Set boxes plumb, level, square and flush with finished building surfaces within one-sixteenth inch for each condition. Set boxes so that box openings in building surfaces are within one-eighth inch of edge of material cut-out and fill tight to box with building materials. Single gang opening shall extend at least to the finished wall surface and not more than 1/8" beyond the finished wall surface. Provide backing for boxes using structural material to prevent rotation on studs or joists.
   b. Install floor boxes level and adjust to finished floor surface.
7. Surface-mounted outlet boxes:
   a. For boxes surface-mounted on finished walls, provide Wiremold outlet box or equivalent. Cut box as necessary to accept conduit.
   b. For boxes surface-mounted on unfinished walls (i.e. electrical rooms, mechanical rooms), provide 4" x 4" (minimum) outlet box with single gang cover.

3.4.2.2.6 Floor Boxes

1. Provide floor boxes as shown on Contract Documents.
2. Set device boxes plumb, level, square and flush with floor, within 1/16" tolerance for each condition.
3. For floor boxes with combined power and telecommunications circuits, provide metal dividers to separate power from telecommunications circuits.

3.4.2.2.7 Junction Boxes

1. Provide junction boxes as shown on Contract Documents and as required.
   a. Where sizing is not shown on Contract Documents, size junction box length and depth per the size of the feeder conduit in the following table:

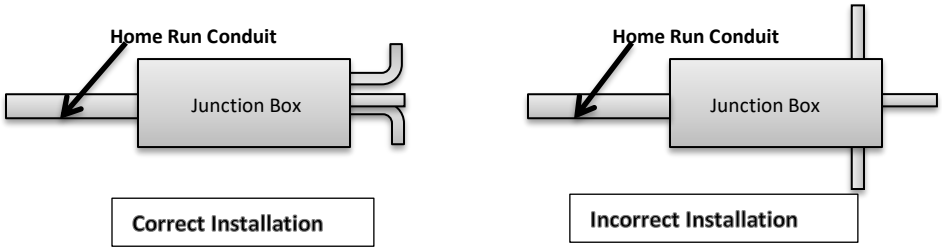
Feeder Size	Box Length	Box Depth
1"	12"	4"
1 – ¼ "	12"	4"
1 – ½ "	12"	4"
2"	24"	4"
2 – ½ "	24"	6"
3"	36"	6"
3 – ½ "	48"	6"
4"	60"	6"

b. Where sizing is not shown in Contract Documents, size the junction box using the table below. Select the width of the largest conduit on the distribution side of the box. For each additional distribution conduit, add the "Increase Width" value associated with its size to the largest distribution conduit's box width. For example, if the distribution side of the junction box has one 1¼" distribution conduit and three 1" distribution conduits, the total distribution-side width is 6" + 2" + 2" + 2" = 12".
c. Repeat the above process for the feeder side of the junction box. A single conduit typically feeds junction boxes, so unless the box has more than one feeder conduit, the "Increase Width" is unnecessary. For example, if the feeder side of the junction box has two 2" feeder conduits the total feeder-side width is 8" + 5" = 13".
d. The larger of the two width calculations (distribution side vs. feeder side) shall be the width of the junction box. For example, if the distribution-side width is 10" and the feeder-side width is 13", provide a 13" wide junction box.

Conduit Size	Box Width	For each additional conduit increase width
1"	4"	2"
1 – ¼ "	6"	3"
1 – ½ "	8"	4"
2"	8"	5"
2 – ½ "	10"	6"
3"	12"	6"
3 – ½ "	12"	6"
4"	15"	8"

2. Do not substitute a junction box for a 90-degree bend. 90-degree condulets (LB's) are not acceptable.
3. Install junction boxes in a location readily accessible both at time of construction and after building occupation. Do not install junction boxes in inaccessible interstitial building spaces.
4. Where junction boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4 feet above grid.
5. Install hinged-cover enclosures and cabinets plumb and supported at each corner.
6. Install junction boxes so that the access door opens from the side where the cable installer will normally work – typically from the bottom (floor side) of the box.
    a. Where a junction box is installed in a ceiling space, coordinate with other trades to provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
    b. Provide a lockable access cover (or junction box door if junction box is exposed) in hard lid ceilings.

7. Install junction boxes so that conduits enter and exit at opposite ends of the box:



3.4.2.2.8 Pull Boxes

1. Provide pull boxes as shown on Contract Documents and as required.
    a. Where sizing is not shown on Contract Documents, size pull boxes as follows:

Size of Largest Conduit	Box Width	Box Length	Box Depth
1”	4”	12”	4”
1 – ¼”	6”	12”	4”
1 – ½”	8”	12”	4”
2”	8”	24”	4”
2 – ½”	10”	24”	6”
3”	12”	36”	6”
3 – ½”	12”	48”	6”
4”	15”	60”	6”

    b. Where a pull box is required with conduits 1” or smaller, an outlet box may be used as a pull box. Where using an outlet box as a pull box, it must be dedicated for use as a pull box and shall not host cable termination hardware.
2. Do not substitute a pull box for a 90-degree bend. 90-degree condulets (LB’s) are not acceptable.
3. Install pull boxes in an accessible location, readily accessible at time of construction and after building occupation. Do not install pull boxes in inaccessible interstitial building space.
4. Where mounting pull boxes on ceiling structure above ceiling grid, do not mount higher than 4’ above grid (mount on wall instead).
5. Install hinged-cover enclosures and cabinets plumb and supported at each corner.
6. Install pull boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side, of the box).
    a. Where a pull box is installed in a ceiling space, provide full access to the junction box door and adequate working room for installation personnel and proper looping of cable during installation.
    b. Provide a lockable access cover (or pull box door if pull box is exposed) in hard lid ceilings.
7. Install pull boxes so that conduits enter and exit at opposite ends of the box.

3.5 Cable Trays

3.5.1 General

A. Provide all materials and labor for installing a code-compliant, complete cable tray system for communications infrastructure as shown on Contract Documents. This work shall also include materials, equipment and apparatus not explicitly mentioned herein or noted in the Contract Document, but which are required for a complete system.
B. Cable tray system installation shall comply with ANSI-TIA #568-E.0-E.5, #569-E Best Practices and follow CSI MasterFormat Division 270536. For more details, see “Codes and Standards” on page 77.
C. Cable tray equipment shall comply with NEC requirements, and applicable portions of NFPA 70B and NECA’s “Standards of Installation” pertaining to general electrical installation practices. See “Product Specifications and Requirements” on page 60.
D. For labeling details, see “Labeling“ on page 32.

3.5.2 Execution

3.5.2.1 INSTALLATION

A. Provide cable tray in the locations and widths shown on Contract Documents and per manufacturer’s requirements and industry practices (NEMA VE 2).
    a. Install cable tray plumb, level, and square with finished building surfaces.
    b. Provide factory-manufactured connection hardware between each cable tray segment. Cable tray segments shall be mutually aligned. Install connection hardware per the manufacturer’s requirements.
    c. Cable tray elevation changes shall be gradual.
B. Provide slots/sleeves where required and where shown on Contract Documents. Provide hammer-drilling, core drilling, and saw cutting where required. Seal and firestop (firestop only if fire rated barrier) between slot/sleeve and cable tray.
C. Cable tray routing:
    a. Route cable tray as shown on Contract Documents. Where not shown, route cable tray in the most direct route possible, parallel to building lines.
    b. Do not route cable tray through areas in which flammable material may be stored or through wet, hazardous, or corrosive areas.
D. Cable tray clearance:
    a. Requirements for accessibility:
        i. Maintain a clearance of 6” between top of cable tray and ceiling structure or other equipment or raceway.
        ii. Maintain a clearance of 8” between at least one side of cable tray and nearby objects.
        iii. Maintain a clearance of 6” between bottom of cable tray and ceiling grid or other equipment or raceway.

b. Requirements from sources of electromagnetic interference (EMI):
    i. Maintain a clearance of 5” or more from fluorescent lighting.
    ii. Maintain a clearance of 12” or more from conduit and cables used for electrical power distribution.
    iii. Maintain a clearance of 48” or more from motors or transformers.
    iv. Pathways shall cross perpendicularly to electrical power cables or conduits.
c. Maintain a clearance of at least 6” from parallel runs of flues and steam or hot-water pipes or other heat sources operating at temperatures above one-hundred degrees Fahrenheit.

E. Provide field-fabricated cable tray fittings from straight sections of cable tray using manufacturer-approved tools and per manufacturer’s instructions. Bends shall be long radius. Do not use short radius bends and T-sections unless specified on Contract Documents.
F. Provide cable tray supports per manufacturer’s recommendations.
    a. Attach supports to structural ceiling or walls with hardware or other installation and support aids specifically designed for the cable tray type and weight and required cable weight and volume. Use all threaded rods (ATR) and manufacturer specified attachments. Install ATR using properly sized anchors and attachment hardware. Select ATR to support the maximum load for which the cable tray is designed.
    b. Provide wall-mounted supports where cable trays abut walls. The number of brackets and specified spacing interval depends on the rated load the cable tray must support.
    c. Make supporting attachments on a cable tray not more than 24” from the ends, and at joints between two sections.
    d. Support trays at 5-foot intervals minimum, or more frequently if required by the manufacturer.
    e. Do not attach cable tray supports to ceiling support system or other mechanical support systems.
G. Install tray supports per load criteria of L/240, and as shown on Contract Documents.
H. Install cable trays free of burrs, sharp edges, or projections which may damage cable insulation.
I. Cut wire-type cable tray with a manufacturer-approved cutter with “offset cutting blade” jaws and a minimum 24-inch handle.
    a. The choice and position of the jaws at the point of cut shall allow shearing as close as possible to the intersection of the steel wires.
    b. Cuts shall ensure the integrity of the galvanic protective layer.
J. Provide cable tray sliding or offsetting expansion joints/fittings where the cable tray crosses building expansion joints in addition to where shown on Contract Documents. Provide bonding jumper except where expansion joints are explicitly approved for bonding.

K. Install cable tray sections with gap settings between cable tray sections appropriate for the range of thermal expansion and contraction expected for the space during construction and normal occupancy and operation.
L. Provide barrier strips as recommended by manufacturer.
M. Provide cable tray radius drops where cable trays cross other telecommunications cable trays or ladder rack in addition to where shown on Contract Documents.

3.5.2.2 CLEANING AND PROTECTION

A. After completing installation (including outlet fittings and devices), inspect exposed finish. Remove burrs, dirt, and construction debris. Repair damaged finish, including chips, scratches, and abrasions.
B. Provide final protection and maintain conditions per manufacturer recommendations and accepted industry practice that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
    a. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
    b. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.5.2.3 TESTING

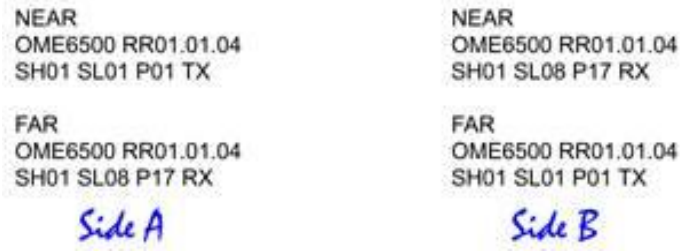
A. Test cable trays to ensure electrical continuity of bonding and grounding connections. Show compliance with maximum grounding resistance per NFPA 70B, Chapter 18.

3.6 Labeling

A. All labeling shall conform to ANSI/TIA-606-C and #607-D (Best Practices).
B. Use only labels that are permanent, permanently fastened, and created by hand-carried label maker or a software-based label making system, such as:
    a. Label-maker: Brady ID Pro Plus or approved equivalent
    b. Labels: Bradymaker Wire Marking Labels WML-511-292 or approved equivalent
C. Do NOT use P-touch labels.
D. Do NOT use handwritten labels.
E. Label cables, outlets, patch panels, and punch blocks with room number in which outlet is located, followed by a single letter suffix to indicate specific outlet within room, i.e., S2107A, S2107B. Indicate riser cables by an R then pair or cable number.

Table 2: Labeling Instructions by Component

Building Component	**Labeling Instructions**
Racks	a) For new installations, affix relay rack labels to the Top/Front, Bottom/Front, Top/Rear, and Bottom/Rear of the relay racks. b) Labels shall be white with black lettering. c) Count relay racks/subsets left to right in all ICT spaces.

	d) For existing relay racks, added labels are not required unless specified by the customer or statement of work. e) Group terminations by component type in sequential room numbers. f) Maintain consistency in information on labels. For example: 1. 01.01.01. = 1st Floor, Row/ICT Space #1, Relay Rack #1. 2. 01.01.02. = 1st Floor, Row/ICT Space #1, Relay Rack #2. 3. 02.01.01. = 2nd Floor, Row/ICT Space #1, Relay Rack #1. 4. 02.01.02. = 2nd Floor, Row/ICT Space #1, Relay Rack #2.  
Fiber Distribution Panel and ID Cards	a) Label with P-Touch ½". Include loop identification, site number, panel number and destination information. b) Label all fiber ID cards supplied with each fiber distribution panel with the circuit ID in the corresponding square. 
Fiber Cabling	a) Clearly identify near and far end port information. The top part of the label indicates near end, the bottom indicates far end. For example:  b) Information on the label varies by equipment type. However, label should always include the shelf type, shelf number, relay rack number, and physical port. The label allows up to seven lines of text and should include enough information to enable easy identification and physical termination. c) Place each label 2-3" from boot. d) Place each label on the fiber in a position to allow easy identification without disrupting the fiber.

	e) Place all labels on the fiber to minimally disrupt the cable for visibility and identification of fiber terminations. The label should be visible without having to touch or move the fiber cable. f) Include circuit ID. For example, for a circuit originating at site 0003 and terminating at site 0473, the circuit ID will be 0003-0473. Note: Some OSI Layer #1 Optical Fiber Circuits associated with OCTO's transport, backbone, and distribution rings loop in and out of the same P-PEX/Hub site. In this case, use the following circuit identifiers: 1. Example #1: Circuit 0241-0473-P for Primary Path. 2. Example #2: Circuit 0003-0473-D for Diverse Path.
Busbar Grounding and Bonding	a) Label Primary Busbar with "PBB". b) Label Secondary Bonding Busbars with "SBB-01" "SBB-02" etc. c) Label TBB(s) with "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!" d) Use the following ICT listed grounding-bonding infrastructure connections: GE, GEC, Facility Ground/ACEG, BTC, PBB, TBB (Optional Due to Impedance, Sizing and Cost TBB Related Issues), Building Steel, EDP's, GE's, SBB's, TEBC's, RBC's, RBB's, and UBC's (ANSI-TIA #607-D Best Practices).
Conduits and Pullboxes	a) Label conduits, raceways and boxes as defined in NEC, article 100. b) Listing and labeling agency shall be a "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7. c) Label per ANSI-TIA #569-E.0-E.1 and #569-E (Best Practices).
Power – Rectifier and UPS	Labelling load helps in tracing load cables back to power sources terminating in PDU circuit breakers. This is helpful when a lot of equipment is connected to a single or several PDUs. a) Designate all main power leads from the Load power source terminating at the PDU or individual shelves with C-tags and labels identifying LDs & RTNs. b) Use C-tags to label load and return cables. C-tags shall have a white label with black lettering. Do NOT overlap or extend labels beyond the edges of the P-tag.   c) Customize information on C-tags to match power system nameplates. a. For Eltek Valere AC-to-DC converting rectifier equipment, for example: "Int-shelf A/5-rect/Dist1/01.01.01/Pos02/-48V 40Amps" i. "Int-shelf" - rack mountable Eltek integrated rectifier shelf A. (Use B for a second shelf on the same rack, C for a third, and so on.) ii. "5-rect" - 5x2500W rack mountable rectifier shelf model. iii. "Dist1" - DC distribution system (panel) intergraded with the rectifier shelf for distributing the source current to several connected loads. Other systems use a second distribution system; in this case use "Dist2" on the tag. iv. "01.01.01" - rack on which the rectifier shelf is installed.

<table>
<tr><td></td><td>
v. “Pos02” - breaker position within a specific DC distribution system (panel). One rack-mountable DC distribution system can have up to 24 breaker positions.
vi. “-48V 40amps” - voltage and current the power cable routes from the source side to the load side.
2. For APC UPS systems, for example: “APC UPS A/1000VA/01.01.01/Pos01/ 20A-120V”
i. “APC UPS A” - first rack mounted APC UPS used as power source (Use B for a second UPS on the same rack, C for a third and so on..)
ii. “1000VA” - rated power capacity of the APC UPS.
iii. “01.01.01” - rack on which the APC UPS is installed.
iv. “Pos01” - first load output outlet on the top left of the AC distribution panel on the output side of the APC UPS, (Pos2 can be the next outlet to the right and so on…)
v. “20A-120V” - AC voltage and AC current rating of outlet on output side of the APC UPS.
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<tr><td>Power – Inverter AC Outlet</td><td>
Exceltech 200W to 1100W rated rack-mountable DC to AC inverters are used to connect to rectifier systems on one side and produce AC power on the load side.
a) Label each outlet with permanent self-adhesive label with minimum 3/16” high characters.
b) Label load cables connected to inverters as is done for APC UPSs. For example: “Inverter A/1100W/01.01.01/Pos01/20A-120V”
1. “Inverter A” - first rack mounted inverter used as the power source. (Use B for a second inverter on the same rack, C for a third, and so on.)
2. “1100VA” - rated power capacity of the inverter.
3. “01.01.01” - rack on which the inverter is installed.
4. “Pos01” - first load output outlet on the top left on the output side of the inverter (Pos2 can be the next outlet to the right and so on…) (See below a sample of an inverter outlet labeling.)
5. “20A-120V” - AC voltage and AC current rating of outlet on output side of inverter.


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<tr><td>Cabling – Low Voltage</td><td>
a) Follow all ANSI/TIA-606-C and #607-D standards for labeling.
b) Include both Near End and Far End termination assignments.
c) Label each cable with permanent self-adhesive label with minimum 1/8” high characters, in following locations:
1. Inside TO receptacle box at the work area.
2. Behind the TR patch panel or termination block.
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<tr><td>Patch Panel</td><td>a) Use labels on face of data patch panels.</td></tr>
</table>

	b) Provide facility assignment records in a protective cover at each TR that is specific to the facilities terminated therein.
Termination Block	a) Use color-coded labels for each termination field that conforms to ANSI/TIA-606(B) standard color codes for termination blocks. b) Mount termination blocks on color-coded backboards.
Face Plate	a) Use recessed designation windows to facilitate labeling and identification. b) Include a clear plastic cover to protect labels in the designation window. c) Have mounting screws located under recessed designation windows.
Wireless AP	a) Affix label to faceplate; do not just place behind clear plastic strip. b) Sequence work area outlets from left to right, clockwise from entry door.

4 Equipment Room and Telecommunications Room Fittings

4.1 General

A. This section includes minimum requirements and installation methods for:
    a. Equipment racks and cable routing hardware
    b. Copper terminations equipment
    c. Fiber termination equipment
    d. Grounding and bonding
B. Make available all services, labor, materials, tools, and equipment essential for the complete and proper installation within Telecommunications Rooms (TRs) and Equipment Rooms (ERs) as specified in the Contract Documents.
C. All work shall comply with ANSI-TIA #568-E.0-E.5, #569-D Best Practices and follow CSI MasterFormat Division 271100.

4.1.1 Architectural and Communications Requirements

A. Design new TRs and ERs to comply with the space, electrical, and environmental requirements of ANSI/TIA-569-E – Commercial Building Standard for Telecommunications Pathways and Spaces. Use of smaller spaces or enclosures is not permitted without prior written approval from DC-Net.
B. Design the locations for all TRs and ERs to be within a 150’ radius of all areas served to maintain ANSI/TIA distance standards for telecommunications cabling.
C. All new TRs and ERs require corridor access with the door to swing out. TRs and ERs shall comply with common area access requirements. No other rooms shall lead directly to or from the TR or ER.
D. Cover all walls of TRs and ERs with rigidly fixed ¾” A-C fire-resistant or non-combustible plywood backboard, void free, 8 feet high, painted with two coats of light-colored fire-retardant paint.
E. TRs and ERs shall be open to the structure above (no suspended ceiling).
F. Seal the floor, walls, and ceiling of TRs and ERs to reduce dust. The floor shall be sealed concrete.
G. TRs and ERs shall not be shared for any other purposes including custodial, access services, electrical, mechanical, storage, etc.
H. Equipment not related to the support of the TR or ER (e.g., piping, ductwork, pneumatic piping, electrical equipment, plumbing, etc.) should not be installed in, pass through, or enter the room.
I. Do not add equipment, hardware, piping, etc. in or near any TR or ER that will change the temperature or humidity of these rooms, without written agreement from DC-Net prior to design and installation.

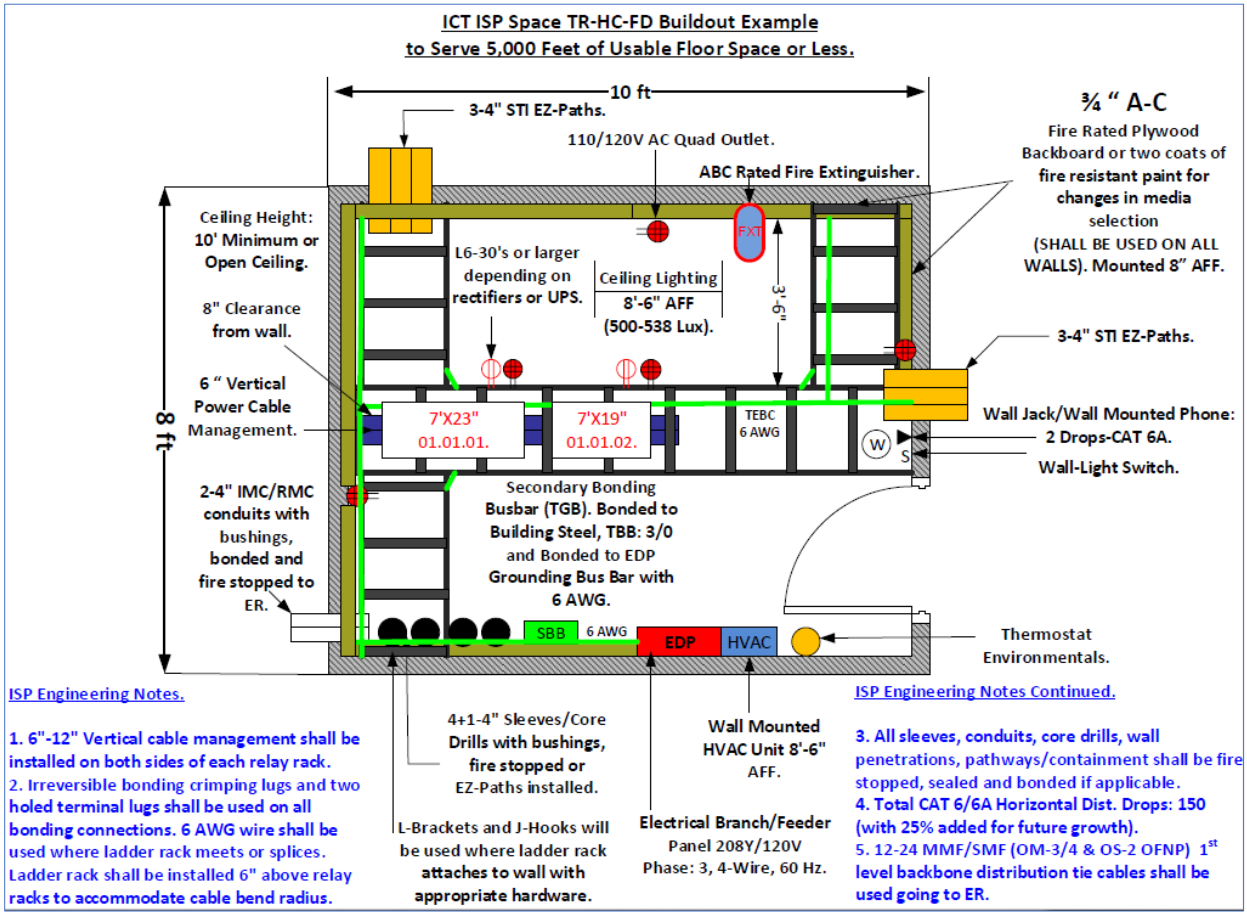
J. Design the ER to allow future UPS floor space in the footprint. A minimum of 10 ft. x 16 ft. is recommended – larger depending on the overall usable and non-usable floor space associated with any given building per ANSI/TIA-569-D. This additional space enables public safety, future growth, proper clearances, and technician access for preventive maintenance. Install empty conduits running from the UPS location to each data closet. Ensure enough wall space is available for future electrical breaker panels that will feed all TRs.
K. New TRs and ERs shall not be adjacent to any electrical room or room containing a transformer or motors. Configure any electrical power systems in or adjacent to TRs and ERs so that their electromagnetic fields, (EMC/EMI, harmonics, AC-DC waveforms and other electrical principals of transmission related issues) do not interfere with telecom cabling or equipment.
L. Install a minimum of two 4" conduits in all drywall ceilings greater than 3 feet wide and at all corners that are drywall.
M. As-built files shall be a part of the final punch list and are not complete until DC-Net receives the final as-built files.
N. Use DC-Net supplied prints for design on all projects with updates for each project.

4.1.2 Execution

4.1.2.1 EQUIPMENT ROOM/TELECOMMUNICATIONS ROOM DIMENSIONS

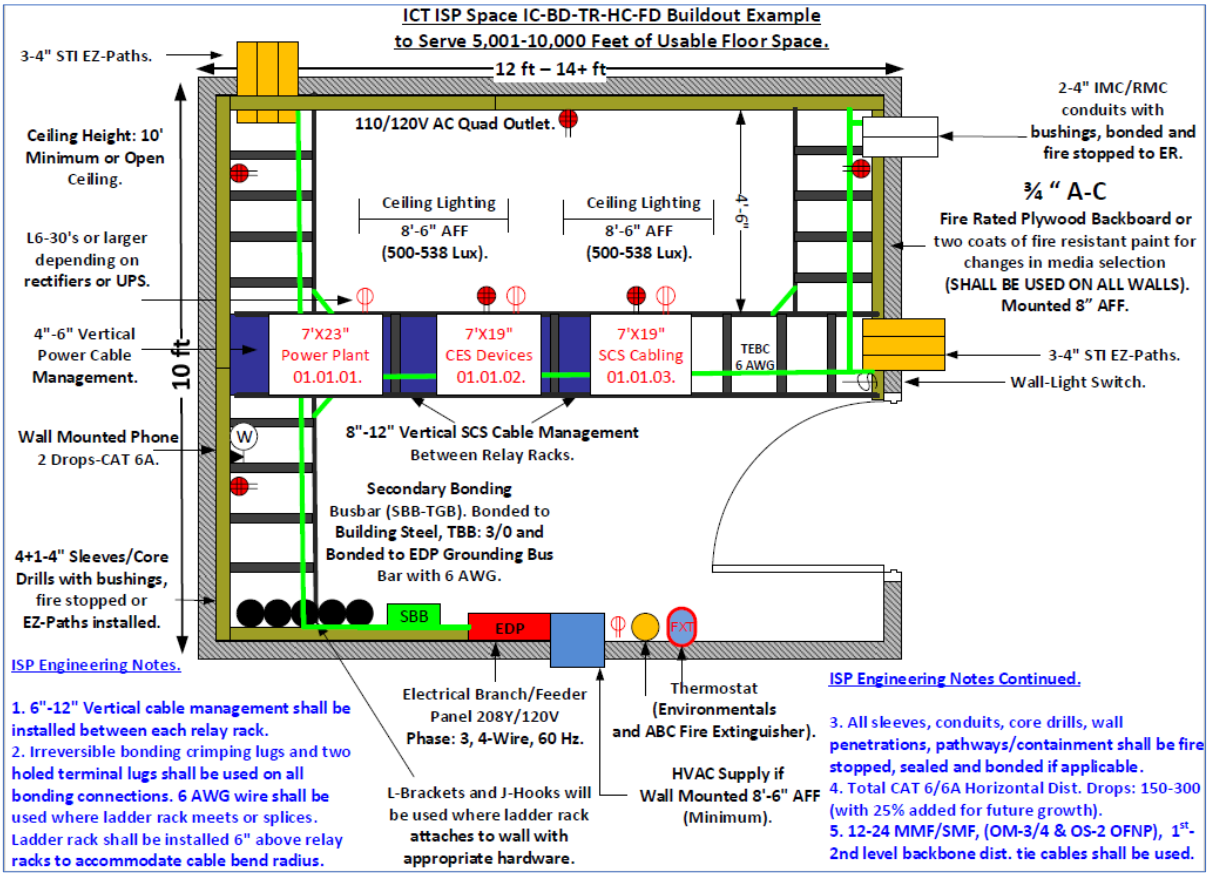
A. **OCTO Model 1 - TR-HC-FD:** At least 8' x 10 '. Serves 0-5,000' usable floor space.

Figure 7: ICT Space - Model 1



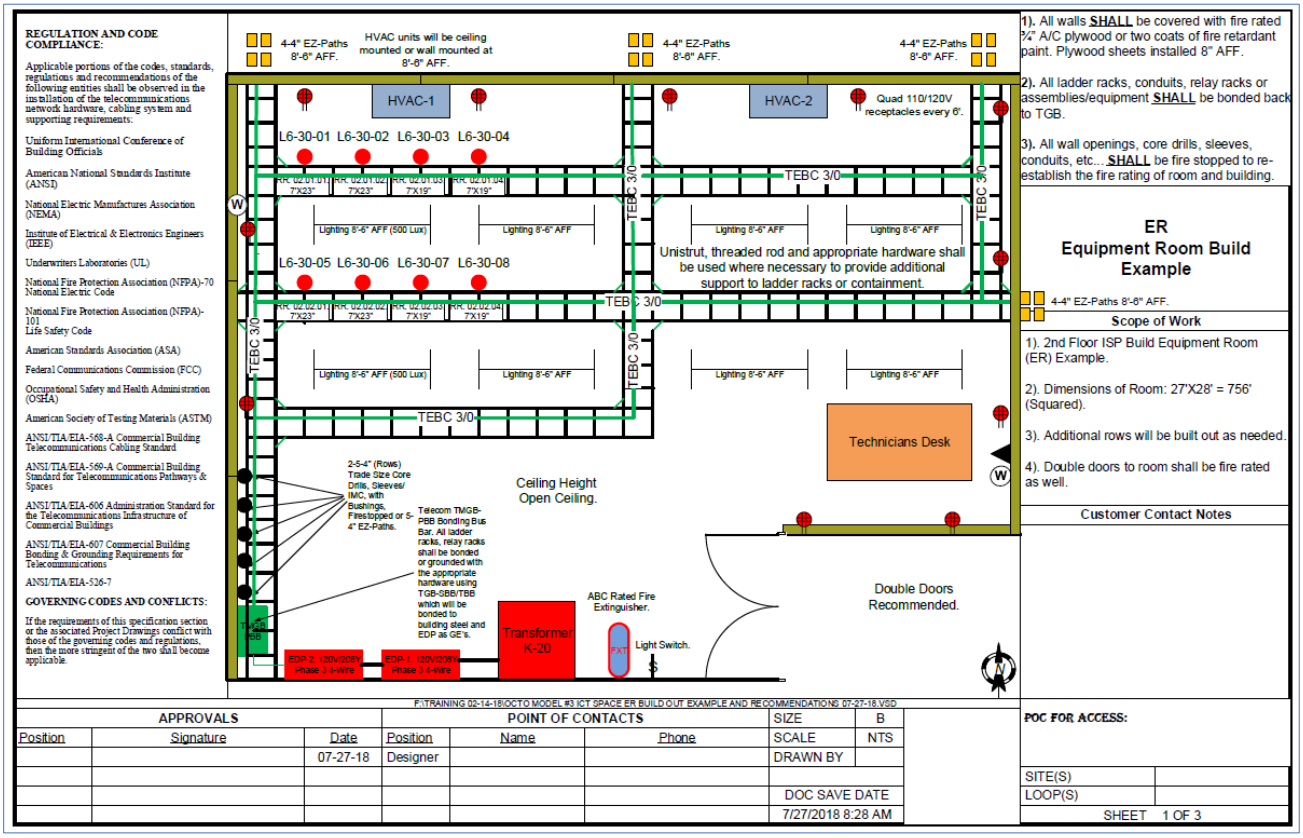
B. **OCTO Model #2 - IC-BD-TR-HC-FD:** At least 10' x 12'. Serves 5,001-10,000 feet usable floor space. 10' x 14' or larger dimensions are recommended to support larger vertical cable managements, public safety, moves/adds/changes, renovation work, clearances, large amounts of cross connecting, and engineer/technician access for preventive maintenance. (See ANSI-TIA #569-E Best Practices).
    a. In multiple floored buildings, every floor should have at least one ICT space. Add ICT spaces for every additional 10,000 feet of usable/non-usable floor space served on any given floor within any building.
    b. Stack all ICT spaces vertically between floors if possible.
    c. See ANSI-TIA #569-E Best Practices for additional recommendations.

Figure 8: ICT Space - Model 2



C. **OCTO Model #3 - ER-MC-CD-IC-BD-TR-HC-FD**: At least 10' X 16' or larger depending on the overall usable and non-usable floor space associated with the building (per ANSI-TIA #569-E Best Practices).

Figure 9: ICT Space - Model 3



4.1.2.2 RACKS AND CABLE ROUTING HARDWARE

A. TRs and ERs may be equipped with some existing hardware, such as plywood backboards, grounding bus bars, equipment racks, ladder cable runway, horizontal and vertical cable management, and copper and fiber termination equipment. Existing hardware already be in place will be shown on the project drawings. (For details, see “Product Specifications and Requirements” on page 60.)

B. Verify that TR and ER conditions are as shown on project drawings. Provide notification in writing of conditions deviating from drawings or detrimental to proper completion of the work.

C. Beginning installation in TRs and ERs indicates acceptance of existing conditions.

D. Install new equipment racks with vertical and horizontal cable management in TRs and ERs as required for project and as shown on drawings. Securely anchor all equipment racks to the concrete floor using minimum 3/8” hardware or as specified by rack manufacturer.

E. Install new ladder cable runway for cable routing in TRs and ERs as required for the project and as shown on drawings. Securely anchor all ladder cable runway to the walls with support kits and brackets as specified by manufacturer. Secure equipment racks to ladder cable runway with all-thread covered with EMT conduit sleeve.

F. Install plywood backboard on TR and ER walls as required for the project and as shown on drawings. Anchor all plywood backboard securely to the walls.
G. Install D-Rings on plywood backboard for cable routing in TRs and ERs as required for the project and as shown on drawings. Do not use D-Rings as a substitute for a telecommunication pathway.
H. Support all new cables using listed ladder rack, basket tray, cable runway, cable management hardware and shall be neatly dressed-out in all TRs and ERs.
I. Clamp all new cables at the entrance to the TRs and ERs for strain relief.
J. Firestop all sleeves and conduit openings after the cable installation is complete.
K. Follow the DC-Net standard format as shown in the typical rack layout drawings for hardware layout in the racks.
L. Coordinate equipment placement with DC-Net staff.

4.1.2.3 UPS

A. Provide one (1) UPS unit in each data equipment rack. For UPS specifications, see “Equipment and Telecommunications Rooms – Rack, Power, and Lighting” on page 65.

4.1.2.4 SURGE PROTECTION

A. The Contractor shall:
    a. Provide transient surge protection on the AC power feeds to all equipment, feeds and on all telephone station and central office lines leaving or entering the main building and all rooms (as applicable). This protection shall include equipment with switches, hubs, and similar devices.
    b. Provide devices per DC-Net surge protector specifications. See “Product Specifications and Requirements” on page 60.
    c. Note in submittal drawings the type and location of these protection devices and all wiring information.
    d. Provide ventilation panels, louvers, blower fans, etc., as required to provide heat dissipation to conform to the equipment manufacturers’ environmental specifications.
    e. Ground surge protection devices as required by the equipment manufacturers and comply with UL, ANSI, NEC, State and local agencies.

4.1.2.5 PATCH PANELS

A. Provide instructions for installation of patch panel.
B. For specifications, see “Cabling, Patch Panels, and Supporting Hardware” on page 75.

4.1.2.6 GROUNDING AND BONDING

See also “Grounding and Bonding” on page 16.

A. Mount new SBBs on plywood backboard in TRs as shown on project drawings. Coordinate SBB locations with DC-Net.
B. Mount new PBB on plywood backboard in main ER as shown on project drawings. Coordinate PBB location with DC-Net.

C. Install new TBB from the PBB in the ER to the SBBs in the TRs as shown on project drawings. Connect the TBB to the PBB and SBBs per ANSI/TIA-607-D and NEC. Place all grounding conductors, leaving the ER and TRs in a separate conduit from all communication cabling.
D. Bond all metallic surfaces of new racks, ladder cable runway, and equipment in TRs and ERs to the SBB or PBB in the same room with #6 AWG grounding wire as straight as possible.
E. Bond all metallic raceways (conduit, cable tray, etc.) entering TRs and ERs to the SBB or PBB in the same room with #6 AWG grounding wire as straight as possible.
F. Install all grounding items in compliance with CSI MasterFormat Division 26 – Electrical and NEC.

5 Backbone Cabling

Content in this section follows CSI MasterFormat Division 271300.

5.1 Communications Copper Backbone Cabling

5.1.1 General

A. This section provides the requirements for the installation of multi-pair unshielded twisted pair (UTP) cables and associated hardware for copper backbone cabling.
B. Content in this section follows CSI MasterFormat Division 271313.
C. Install all structural cabling elements per the most stringent requirements of the NEC, local building codes, ANSI/TIA commercial building wiring standards, ANSI/NECA/BICSI 568.2006 standard or current edition for installing telecommunications systems and all relevant BICSI manuals. See “Codes and Standards” on page 77.
D. Submit drawings and receive approval from DC-Net’s Project Manager for any deviations from standards or drawings due to field conditions. See “Documentation and Submittals” on page 11.
E. See “Product Specifications and Requirements” on page 60.

5.1.2 Execution

5.1.2.1 GENERAL

A. Backbone cabling systems shall provide interconnections between TRs, ERs, and entrance facilities. The system includes backbone cables, intermediate and main cross-connects, and mechanical terminations used for backbone cross-connects.
B. Use specified pulling tensions and bend radius when installing cables.
C. Consider the proximity of backbone cabling to potential sources of radio frequency interference (RFI) and electromagnetic interference (EMI) when installing cable.
    a. Maintain at least 6” clearance from fluorescent lighting fixtures and electrical conductors up to 2 Kilo-volt-amperes (kVA).
    b. Maintain at least 24” clearance from electrical conductors up to 5 kVA.
    c. Maintain at least 36” clearance from electrical conductors over 5 kVA.
    d. When cabling is required to cross over electrical conductors, do so at a 90-degree angle.
    e. Electrical cabling shall not lie on top of communication cabling.
D. Bond both ends of all cable shields to the appropriate PBB.
E. Label all cabling per specifications. (For details, see “Labeling“ on page 32.)
F. Run all backbone cabling with no splices.
G. Adhere to ANSI/TIA 568-E/569-E specifications regarding bend radius, maximum tensile strength, and maximum vertical rise.

5.1.2.2 INSIDE PLANT CABLE

A. Configure backbone cabling in a logical star topology.
B. Limit backbone to two hierarchal levels of cross-connects. No more than one cross-connect may exist between a main and a horizontal cross-connect and no more than three cross-connects may exist between any two horizontal cross-connects.
C. Document the distance between the terminations in the entrance facility and the main cross-connect and make this available to the access provider.
D. Riser cable shall be supported on every other floor using cabling manufacturer approved supporting hardware.

5.1.2.3 PATCH CABLES

A. Patch color codes are determined by their application. Coordinate patch cord color with the DC-Net Project Manager.
B. Excessive patch cord lengths are not permitted. Appropriately size all patch cords while maintaining proper cable bend radius.

5.1.2.4 TESTING INSIDE PLANT CABLE

A. Perform all copper wiring testing before system cutover. Test *all* horizontal, riser and inter-cabinet wiring pairs for opens, shorts, polarity reversals, transposition and presence of AC voltage.
B. Test multi-pair cables to each TR. Verify that cable runs conform to ANSI/TIA-568-D/E.1 and ANSI/TIA-568-D/E.2 specifications.
C. Testing shall include length, mutual capacitance, characteristic impedance, attenuation, and near-end and far end crosstalk. Ensure all pairs comply with standard requirements or replace these at no cost to DC-Net.
D. Ensure test equipment is specifically rated for the cabling being tested, properly configured, and calibrated per manufacturer's requirements.
E. Submit current calibration certificate(s) for each piece of test equipment to be utilized. Do not perform tests within a test set that has not been calibrated within 6 months prior to testing.
F. Submit complete end-to-end test results and loss budget calculations to DC-Net in electronic format and hard copy. Handwritten test results will be rejected. If special software or license is required to review test data electronically, provide a copy of the software and license with the test data.
G. Give each test a test identification number. For high pair count UTP backbone cables, use the cable identification as the test identification. High-count UTP backbone cables shall be divided into 1-pair increments and each shall have a unique test identifier.
H. Organize and group test data by individual TR with the summary report followed by a detailed test sheet for each cable tested. Sort all results by test identification numbers and bound in 3-ring binders (each no larger than 3" thick).
I. Include a project closeout test report. For details, see "Documentation and Submittals" on page 11.

J. Acceptable copper test sets are Fluke, Agilent Technologies, or an engineer approved equivalent.
K. Test results must be provided prior to acceptance.

5.2 Communications Optical Fiber Backbone Cabling

5.2.1 General

A. This section includes installation and testing requirements for fiber optic systems.
B. Content in this section follows CSI MasterFormat Division Section 271323.
C. Install all structural cabling elements per the most stringent requirements of the NEC, local building codes, ANSI/TIA commercial building wiring standards, ANSI/NECA/BICSI 568.2006 standard or current edition for installing telecommunications systems and all relevant BICSI manuals including 13th TDMM Edition (or most current edition of the BICSI TDMM).
D. For testing requirements and other submittals, see “Documentation and Submittals” on page 11.
E. For product requirements for fiber optic cables, termination hardware and required support apparatus, see “Product Specifications and Requirements” on page 60.

5.2.2 Execution

5.2.2.1 GENERAL

A. Provide fiber optic cabling between facilities and furnish with the quantity of fibers as designed on contract drawings. All fiber cable runs shall be from the same manufacturer and shall be of the same type.
B. Leave enough space in the TR to add patch panels needed for migrating the pull-through, interconnect, or splice to a cross-connection. Leave enough cable slack in the TR to allow movement of cables when migrating to a cross-connection.
C. Leave enough slack in the fiber cable at the termination point to allow for routing cable through the termination hardware and back to a worktable for fiber terminations, plus an additional 3 meters.
D. Provide bend radius control in slack storage so the cable and fiber bend radius limitations are not violated. Store fiber slack in the same room as cable. Slack cable may be stored on walls, cable trays, or enclosures within the TR.
H. Label all cabling per specifications. (For details, see “Labeling“ on page 32.)
E. Run all armored and non-armored fiber optic cable in conduit/innerduct. Run multiple fiber cables in a single conduit/innerduct.
F. Adhere to ANSI/TIA 568-E/569-E specifications regarding bend radius, maximum tensile strength, and maximum vertical rise.

G. Limit the use of field terminated connectors to backbone cabling, campus cabling, or cable vendor specific requirements.
H. Terminate all fiber optic cabling with either SC or LC connectors unless a cable vendor requires a different type of connector for a specific and limited application.
I. When installing fiber cabling:
    a. Do not use deformed fiber optic cable sheaths. Use only approved cable fasteners such as hook and loop.
    b. Do not pull fiber optic cabling with copper cabling.
    c. Do not exceed the fiber optic cable maximum pulling tension.
    d. In multiple fiber optic pulls, pull fiber optic cables of the same weight and design.
    e. Do not exceed the maximum pulling tension of the lowest rated fiber optic cable.
    f. Do not pull fiber optic cable over existing cables. Friction can be excessive and cause damage.
    g. Do not exceed maximum bend radius, both pulling and installed radius.
    h. Do not pull fiber optic cable around sharp corners such as support brackets, rods, etc.
    i. Protect fiber optic connectors when using pre-connectorized cables. Use approved pulling grips.
    j. Use lubricants for all fiber optic cable pulls. Use lubricants approved for use with the fiber optic cable type. Never use detergent-based lubricants when installing loose tube fiber optic cable.
J. Use innerduct to protect non-armored fiber optic cables installed within conduit. If fiber optic cable is to be installed in conduit without any innerducts, install innerducts to sectionalize the conduit. Each innerduct shall have pull tapes/line in each empty innerduct.
K. Do not allow fiber optic cables to provide support for other cables or hardware. Never secure other cables or hardware to fiber optic cabling. Individually supported cable may be taped or tied together every 3 meters for cable management but not for support.
L. When routing fiber optic cabling along walls to the termination or splice enclosure, protect fiber optic cabling by installing in innerduct. Place fiber optic warning signs along innerduct. Ensure enough cable slack to allow relocating fiber optic termination hardware to any potential installation area in the room.
M. Follow the ANSI/TIA 598 color code chart for fiber optic cabling termination. Follow the correct fiber polarity to retain this through the cabling system. Install fiber cabling to pair an odd-numbered fiber with the next sequential even-numbered fiber. Install each fiber pair in a pair crossover orientation. Off-numbered fibers at position A at one end are at position B at the other end. Even-numbered fibers at position B at one end are at position A at the other end.

5.2.2.2 INSIDE PLANT FIBER

A. Support riser cable on every other floor using cabling manufacturer approved supporting hardware.
B. Install vertical fiber optic cable placement by working from the top down when possible.

C. Install a split wire mesh support grip at the top of each run. Fiber optic cable shall have its own split wire mesh support grip at the top of the run.
D. Provide fiber between the TRs and ER with 12 strands as designated on the contract drawings.
E. Use all fiber from a single manufacturer. Do not use a mix of fibers from different manufacturers without written permission from DC-Net.
F. All multi-mode fiber shall meet specifications as noted in “Fiber Cable, Connectors, Patch Cords, and Terminating and Supporting Hardware” on page 68.

5.2.2.3 TESTING

A. Test all optical fiber cable prior to installing the cable. You must replace cable that is later found defective.
B. Ensure test equipment is specifically rated for the cabling being tested, properly configured, and calibrated per manufacturer’s requirements.
C. Ensure OTDR and OLTS SMF/MMF optical fiber testing plan is based on OSI/Layer #1 Bi-Directional at MMF 850nm/1300nm and SMF 1310nm/1550nm permanent link testing.
D. Test copper-based ICT-SCS Distribution with Level-3/4 testing equipment at a minimum. Complete overall channel testing and establish operational benchmark readings associated with all OCTO ICT SCSC infrastructures/circuits associated with the proposed ICT infrastructure testing plan.
E. Establish System Gain-Dynamic Range, Passive Attenuation, Link Loss Budgets, Power Penalties, System Performance Margins and System Loss Budgets.
    a. Provide calculations indicating the maximum loss budget for each fiber using the following formula:
    (Allowable cable loss per KM) * (KM of Fiber in Link) + (MFR Published Connector Loss) * (Number of Connectors) loss = Maximum Allowable Loss.
    b. Provide loss budgets to DC-Net for review prior to testing.
    c. Notify DC-Net in writing at least 72 hours before the start of testing and provide a complete testing schedule to allow for witnessing of testing.
    d. Submit calibration certificate(s) indicating that test sets have been calibrated by the manufacturer. Do not perform any test with a test set that has not been calibrated within 6 months prior to testing.
    e. End-to-end loss shall be less than the loss budget. Contractor shall bring any link not meeting standard requirements into compliance at no cost to DC-Net.
F. Test Data and Closeout Report. See “Documentation and Submittals” on page 11.
F. Multi-mode:
    a. Perform testing on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end-to-end system. Testing shall consist of a bi-directional end-to-end optical time domain reflectometry (OTDR) trace (all multi-mode strands over 100 meters) and bi-directional end-to-end light source-power meter test (all multi-mode strands). Perform all tests per ANSI/TIA-568-D/E.3 and ANSI/TIA-526-14A Method B: Intrabuilding or Riser. Provide system loss measurements at 850 and 1300 nanometers for all fibers.
G. Single-mode:

a. Perform testing on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end-to-end optical time domain reflectometry (OTDR) trace (all single-mode strands) and a bi-directional end-to-end lightsource-power meter test (all single-mode strands). Performed all tests per ANSI/TIA-568-D/E.3 and ANSI/TIA-526-7 method A and method B. Provide system loss measurements at 1310 and 1550 nanometers for all fibers.

6 Horizontal Cabling

Content in this section follows CSI MasterFormat Division 271500.

6.1 General

A. This section provides requirements for installing 4-pair unshielded twisted pair channels and special systems cabling for distributed antenna systems (DAS), Wi-Fi antennas and security systems. Included are product, installation and testing requirements for the cable channels.
B. The Contractor shall provide a complete and operational, tested, and documented 4-pair UTP system.

6.2 Execution

6.2.1 Cable Routing and Installation

A. Ensure that all communications cabling complies with the requirements of NEC (NFPA-70) Articles: 90, 100, 250, 300, 725, 760, 770, 800 and Chapter #9, and all local building codes per DCRA/DCMR or AHJ. All copper cabling shall bear CM, CMR, CMP and/or other appropriate markings for the environment in which they are installed.
B. Do not bundle cables running in cable tray or duct. Loosely arrange cables in these areas to minimize alien crosstalk.
C. Do not drill or pierce structural concrete on steel members without prior approval from a licensed structural engineer and the AHJ.
D. Install all cable using an independent cabling support system. Do not attach cables to ceiling grid supports and or lay cable directly on the ceiling grid. Do not attach cables to conduits, pipes, or ducts.
E. Do not attach cable to or get support from fire sprinkler systems components or any environmental sensor located in the ceiling space.
F. Ensure all cable runs between the termination hardware and the telecommunications outlet are continuous without any splices.
G. Schedule work to complete all above-ceiling tasks before installing ceiling tile. If ceiling tiles must be removed, coordinate with other trades.
H. Do not run cabling adjacent or parallel to power cabling on fluorescent lighting fixtures.
    a. Maintain at least 6” clearance from fluorescent light fixtures and electrical conductors up to 2 kVA.
    b. Maintain at least 24” clearance from electrical conductors up to 5 kVA.
    c. Maintain at least 36” clearance from electrical cabling more than 5 kVA.
    d. When cabling is needed to crossover electrical conductors, do so at a 90-degree angle.

    e. Electrical cabling cannot lie on top of communications cabling.

I. Install J-Hooks with spacing to meet or exceed the manufacturer's or local code requirements. Standard J-hook spacing is not to exceed 5 feet on center. No more than 48 cables are permitted per J-hook unless cabling manufacturer installation requirements permit it. Secure cables installed in J-hooks using approved cable ties.
J. Securely fasten cable trays using approved materials and methods as recommended by the manufacturer or AHJ. All supporting rod installation intervals shall be for the full load rating of the cable tray, not the rating of the tray with the planned volume of cabling. Cable fill for cable trays shall not exceed 40% of the maximum fill capacity rating of the support allowed by the manufacturers or local AHJ.
K. Cabling placed in ceiling spaces shall maintain:
    a. 3" clear vertical space above cabling and conduits.
    b. 12" clear vertical space above the cable tray.
    c. 3" clear vertical space between the top of the ceiling grid and the bottom of the cable tray.
    d. 3" clear vertical space between the top of the ceiling grid and structured cabling.
    e. Firestopping that meets local and national codes for cabling passing from fire rated areas.
    f. Firestopping for cabling passing from one floor level to another unless cabling is placed inside a fire rated shaft and is approved by the AHJ.
L. Route all telecommunications cabling installed within ceiling spaces or below raised access floors parallel or perpendicular to building structure.
M. Maintain the minimum bend radius, under no-load conditions, for 4-pair UTP cables of 1" or four times the cable diameter across its major axis, whichever is greater.
N. Open cable tray fill ratio shall not exceed 30% or as allowed by code or the AHJ.
O. Cable fill-in conduits and enclosed raceways shall not exceed 38% or as allowed by code or the AHJ (Per NEC/NFPA-70: 1-Cable 53%, 2-Cables 31% and 3 or More Cables 40%).
P. Label all cabling per specifications. See "Labeling" on page 32.

6.2.2 Horizontal Cabling

A. Provide horizontal cables to connect each telecommunications outlet (TO) to the backbone subsystem on the same floor unless noted otherwise.
B. Terminate each horizontal cable onto a dedicated TO and onto termination hardware in the Telecommunications Room (TR).
C. Unless noted otherwise on the telecommunications drawings, use 4-pair unshielded twisted pair (UTP) for horizontal cables for each TO.
D. Install 4-pair UTP cables using a star topology from the TR to each TO. Submit all cable routes and get DC-Net approval before installing any cabling.
E. The length of each run of horizontal cable from the termination point in the TR on each floor to the TO shall not exceed 295 feet (90M).

6.2.3 Voice and Data Cabling

A. Use only 4-pair, unshielded, Category 6+ plenum-rated jacket from each jack to a patch panel in the TR. For horizontal Category 6+ cabling and components specifications, see “Category 6 Cabling, Outlets, and Patch Panels” on page 73.
B. Make sure all voice outlets match Category 6 data outlets specified for the data cabling system.
C. Terminate all backbone cable pairs end-to-end on Category 6 110 type mass termination blocks.
D. Provide a complete data communications system consisting of the following:
    a. Accessories and appurtenances
    b. Cable management devices
    c. Fiber optic cable and terminators (as indicated on drawings)
    d. Copper and fiber patch cables
    e. Remote jacks
    f. Termination/patch panels
    g. Twisted pair data cables

7 Work Areas

This section provides basic specifications, installation instructions, and utilization guidance for work area products and materials.

7.1 Work Area Outlets

A. All Category 6 (Cat 6) work area outlets shall meet or exceed Near End Cross Talk (NEXT) and all other Cat 6 transmission performance requirements for connecting hardware, as specified in ANSI/TIA-568-D.2 Commercial Building Telecommunications Cabling Standard and be part of the UL® LAN Certification and Follow-up program.

7.2 Indoor Wi-Fi Access Points

7.2.1 Design

1. The OCTO/DC-Net Wireless Engineering team designs in-building Wi-Fi for District-managed Wi-Fi systems.
2. The customer provides OCTO with complete floorplan indicating TR serving data patch cords.

7.2.2 Installation

The Contractor shall:

1. Acquire materials per Wi-Fi design requirements.
    a. External – customer procures.
    b. Internal – OCTO procures.
2. Complete horizontal cabling per OCTO requirements. See “Horizontal Cabling” on page 50.
    a. Process:
        i. External – DGS/customer agency vendor installs cabling.
        ii. Internal – OCTO installs cabling.
    b. Requirements:
        i. Use two **orange** Cat 6 cable patch cords for each wireless AP.
        ii. Terminate all Cat 6 cables in the designated locations on Cat 6 Keystone style Jack.
        iii. Do not use RJ45 for direct termination.
        iv. Conduct end-to-end cable testing and provide test results.
3. Install APs following OCTO design and specifications.
    a. Options for who can install APs:
        i. External – DGS/customer agency vendor installs APs.

1. Provide inventory and MAC address of APs.
2. OCTO or customer vendor creates label per OCTO labeling standard and provides as-built AP installation document that includes floor plan, AP location, and exact label information. See "Labeling" on page 32.

ii. Internal – OCTO installs APs.

b. Mount APs:
   i. Place all wireless APs to be aesthetically compatible with their environment.
   ii. APs have a universal mounting bracket that will either snap on the ceiling metal grid or affix to the wall. Mount to the ceiling grid.
   iii. Mounting guidelines:
      1. Drop ceilings 12 feet or less – mount on ceiling grid.
      2. Solid ceilings and ceilings above 12 feet – mount on wall.
         a. Mount 8 feet above floor.
         b. Mount AP to wall using a right-angle mount. For Example: Oberon 1011-00-WH, 1006-CCOAP3800 or 1006-COAP9120 depending on AP model per wireless design.
         c. Use a surface mount box with Cat 6 Keystone style jacks with a printed label and a written label. For example: Panduit CBX2WHAY, Hellermann Tyton SMBDUAL-W or similar product line.
         d. Surface mount box dimensions must be close to 4.9"H x 3.25"W x 1.8"D.
         e. Anchor all surface mount raceway and boxes to the drywall using 1/8" toggle bolts or twist and lock screw anchors.
            i. 1/8" toggle can safely hold 30 lbs. on ½" drywall.
            ii. Twist and lock screw anchors support up to 75 lb. on ½" drywall.
         f. Do not use the double-sided tape that typically comes with the surface mount boxes for mounting.

4. Terminate endpoints:
   a. Terminate at the AP. Wi-Fi cables must be a different color from data cable.
   b. Terminate at the TR.
      i. Patch panel labeling – Team that runs horizontal cabling (see step 2) terminates.
      ii. Patching to network equipment – OCTO terminates.

8 Firestopping

This section references CSI Master Format Division 27 Section 27 05 28.28, “Firestopping, Smoke, and Acoustical Sealing Telecommunications and Data Cabling” (accessed July 19, 2018).

8.1 General

8.1.1 Summary

A. This section includes labor, materials and equipment necessary to complete the installation required for:
    a. Firestopping of through penetrations in fire-rated assemblies.
    b. Smoke and acoustical sealing in non-rated assemblies.
B. For firestopping product and material specifications, see “Firestopping” on page 61.
C. This specification augments Section 07 84 00 Firestopping and sub sections of Section 07 84 00. For more information, see “Firestopping” on page 78.
D. Determine the extent and character of related work and properly coordinate firestopping work specified herein with work specified elsewhere to produce a complete installation.

8.1.2 Performance Requirements

A. **Use fire rated cable pathway devices in fire-rated construction** for ALL low-voltage, video, data and voice cabling, optical fiber raceways and high-voltage cabling where frequent cable moves, adds and changes may occur. Pathways required for high voltage cabling will be detailed on the prints. Devices shall:
    a. Meet the hourly fire-rating of fire rated wall and or floor penetrated.
    b. Be tested for the surrounding construction and cable types involved.
    c. Have UL Systems permitting cable loads from “Zero to 100% Visual Fill.” This requirement eliminates the need for fill-ratio calculations to be made by cable technicians to ensure cable load is within maximum allowed by UL System.
    d. Not have inner fabric liner that tightens around and compresses cables tightly together, potentially causing cable damage or interference.
    e. Be “Zero-Maintenance,” defined as: No action required by cabling technician to open and/or close pathway for cable moves, adds, or changes, such as:
        i. Opening or closing doors.
        ii. Spinning rings to open or close fabric liner.
        iii. Removal or replacement of any material including firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.

iv. Evaluation Services Report from an accredited Nationally Recognized Third-party Laboratory certifying compliance with Zero-Maintenance and all relevant codes and standards.

f. Have engineered pathways so that two or more devices may be ganged together for larger cable capacities.
g. Have engineered pathways to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing cable.
h. Ensure cable pathway devices passing vertically through floors have equal F & T Rating. (See UL System # F-A-3037, Item #4 "EZ-PATH Grid T Rating Kit" Part # TRK444.)
i. Affix adhesive wall label immediately adjacent to devices with the device manufacturer and the corresponding UL System number installed.

B. **Use non-rated cable pathway devices in non-fire-rated construction** for ALL low-voltage, video, data and voice cabling, optical fiber raceways and high-voltage cabling where frequent cable moves, adds, and changes may occur. Pathways required for high voltage cabling will be detailed on the prints. Devices shall:
   a. Limit the movement of smoke and sound of the wall and/or floor penetrated.
   b. Restore the STC Rating of the penetrated assembly.
   c. Provide L Ratings of <1 CFM when empty and <2.5 CFM at all other loading up to 100 percent.
   d. Accommodate cable loads from "Zero to 100% Visual Fill."
   e. Not have inner fabric liner that tightens around and compresses cables tightly together, potentially causing cable damage or interference.
   f. Be "Zero-Maintenance," defined as: No action required by cabling technician to open and/or close pathway for cable moves, adds, or changes:
      i. Opening or closing doors.
      ii. Spinning rings to open or close fabric liner.
      iii. Removal or replacement of any material including firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.
      iv. Provide letter from manufacturer certifying Zero Maintenance compliance.
   g. Have engineered pathways so that two or more devices may be ganged together for larger cable capacities.
   h. Have engineered pathways to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing cable.
   i. Affix adhesive wall label immediately adjacent to devices with the device manufacturer and the corresponding UL System number installed.

C. You can use a fire-rated cable grommet as an alternate to a fire-rated or non-rated cable pathway device for single low voltage cables penetrating one or two-hour, gypsum board/stud wall assemblies or non-rated assemblies. For product specifications, see "Firestopping" on page 61.
D. Where non-mechanical pathways must be used, such as sealing (caulking) around single or grouped conduits, provide products that upon curing do not re-emulsify, dissolve,

leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction. Provide a letter from the manufacturer certifying compliance.

E. Replace conduit sleeves in walls and floors with cable.
    a. When installing individually in floors, pass devices through core-drilled opening utilizing tested floor plates.
    b. When ganging multiple units in floors, anchor devices by means of a tested grid.
    c. When installing individually in walls, pass devices through core drilled opening utilizing tested wall plates or integrated flanges.
    d. When ganging multiple units in walls, anchor devices by means of a tested grid.
F. Terminate the cable tray at each barrier and resume on the other side so that cables pass independently through devices. Properly support the cable tray on each side of the barrier.

Note to Specifier: Coordinate drawings to show cable tray terminating at wall or floor and resuming on other side.

8.1.3 Quality Assurance

A. Provide firestopping systems that meet the following requirements:
    a. Perform firestopping tests only by a qualified, UL listed testing and inspection agency or another agency acceptable to AHJs.
    b. Use firestopping products that have the classification marking of a qualified testing and inspection agency.
B. Installers shall be experienced in performing work of this section and trained/certified by the manufacture or equivalent to use or apply firestopping materials, compounds, assemblies or hardware associated with the designing or implementation of OCTO's ICT and structured cabling pathways and spaces in any building within the District of Columbia per DCRA-DCMR and NEC-NFPA code requirements.

8.1.4 Delivery, Storage, and Handling

A. Use only manufacturer's original, unopened, undamaged containers with identification labels intact showing product and manufacturer, date of manufacture, lot number, shelf life if applicable, qualified testing and inspection agency's classification marking, and mixing instructions for multicomponent products.
B. Handle and store products per manufacturer's recommendations published in technical materials. Leave products wrapped or otherwise protected from exposure to harmful weather conditions and at temperature and humidity conditions recommended by the manufacturer until required for installation.

8.1.5 Project Conditions

A. Do not install products when ambient or substrate temperatures and conditions (wet due to rain, frost, condensation or other dampness) are outside limitations recommended by manufacturer.
B. Maintain minimum temperature before, during, and for a minimum three days after installation of materials.
C. Do not use materials that contain flammable solvents.
D. Coordinate construction of opening and penetrating items to ensure that through-penetration firestop systems are installed per specified requirements.
E. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
F. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

8.2 Execution

8.2.1 Examination

A. Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer's installation instructions and technical information.
B. Surfaces shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellants, and any other substances that may inhibit optimum adhesion.
C. Provide masking and temporary covering to protect adjacent surfaces.
D. Do not proceed until unsatisfactory conditions have been corrected.

8.2.2 Installation

A. Install systems per Performance Criteria and the conditions of testing and classification as specified in the published design.
B. Comply with manufacturer's instructions for installation of products.
C. Maintain the fire rating of all penetrated fire barriers. Fire stop and seal all penetrations made during construction.
D. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
E. Install firestops per manufacturer's detailed installation procedures.
F. Install firestops per fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards in "Codes and Standards" on page 77. Apply sealing material in a manner acceptable to the local fire and building authorities.

G. For demolition work, apply firestopping to open penetrations in fire rated barriers where cable is removed. Apply firestopping regardless of whether the penetrations are used for new cable or left empty after construction is complete.
H. Firestopping material used to seal open penetrations through which cable passes shall be re-usable/re-enterable.

8.2.3 Field Quality Control

A. Keep areas of work accessible until inspection by AHJs. Where deficiencies are found, repair firestopping products so they comply with requirements.

8.2.4 Adjusting and Cleaning

A. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
B. Clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling as work progresses.

8.2.5 Schedules

Table 3: Firestopping Schedule by Penetrant Type

Penetrant Type	Concrete Floor	Concrete Wall	Gypsum Board Wall
Blank Opening	C-AJ-0100, C-AJ-0101, C-AJ-0113, C-AJ-0116	C-AJ-0100, C-AJ-0101, C-AJ-0113, C-AJ-0116	W-L-0020, W-L-0034
Metal Conduits	C-AJ-1080, C-AJ-1240, C-AJ-1353	C-AJ-1080, W-J-1098, W-J-1100	W-L-1049, W-L-1222, W-L-1168
Plastic Conduits/Raceways	C-AJ-2140, C-AJ-2292, F-A-2186, F-A-2210, F-A-2225	C-AJ-2038, C-AJ-2108, C-AJ-2578, C-AJ-2586, W-J-2018, W-J-2076	W-L-2059, W-L-2074, W-L-2093, W-L-2241
Cables	C-AJ-3214, C-AJ-3231, F-A-3015, F-A-3021, F-A-3054	C-AJ-3214, C-AJ-3231, W-J-3098, W-J-3099, W-J-3124, W-J-3150, W-J-3180	W-L-3219, W-L-3248, W-L-3287, W-L-3356, W-L-3377, W-L-3378, W-L-3379, W-L-3390
Cable Trays	C-AJ-3317, C-AJ-8181, C-AJ-4029, F-A-3015, F-A-3037	C-AJ-8181, W-J-4021, W-J-4022, W-J-4033, W-J-3098, W-J-3145, W-J-3158	W-L-3218, W-L-3271, W-L-3286, W-L-3306, W-L-4008, W-L-4029, W-L-4043, W-L-8073

8.2.6 Documentation

A. Place system stickers on each side of wall penetrations.
B. Place a reproduction (photocopy) of the UL System description in a document protector and mount to the wall next to the wall penetration. Highlight the section of the system description that list the allowed cable types.

9 Product Specifications and Requirements

9.1 Grounding and Bonding

A. Materials shall consist of busbars, supports, bonding conductors and other incidentals and accessories as required.
B. All components shall be Listed by a NRTL.

Component	Requirements	Acceptable Manufacturers
Telecommunications main grounding-primary bonding busbar (TMGB-PBB)	Provide and install at the telecommunications service entrance (or as indicated on the drawings). a) Shall be a predrilled copper busbar with holes for use with correctly matched listed lugs and hardware. b) Shall have minimum dimensions of 0.25" thick by 4" wide by 16" long. Increase length as necessary to provide all connections plus 25% spare capacity.	a) Chatsworth b) Erico c) Harger d) Hoffman e) Panduit f) Or listed approved equivalent
Telecommunications grounding-secondary bonding busbar (TGB-SBB)	Provide and install in each telecommunications room. a) Shall be a predrilled copper busbar with holes for use with correctly matched listed lugs and hardware. b) Shall have minimum dimensions of 0.25" thick by 2" wide by 12" long. Increase length as necessary to provide all connections plus 25% spare capacity.	a) Chatsworth b) Erico c) Harger d) Hoffman e) Panduit f) Or listed approved equivalent
Bonding conductor for telecommunications (BCT-BTC)	a) Shall be copper and may be insulated. b) Shall be Listed for the application when insulated. c) Shall be as a minimum, the same size as the largest TBB.	a) Harger b) Or listed approved equivalent
Telecommunications bonding busbar (TBB) (optional)	a) Shall be copper and may be insulated. b) Shall be listed for the application when insulated. c) Shall be sized at 2 kcmil per linear foot of conductor length up to a maximum size of No. 3/0 AWG.	
Grounding Equalizer (GE)	a) Shall be copper and may be insulated. b) Shall be listed for the application when insulated. c) Shall be as a minimum, the same size as the largest TBB.	a) Harger b) Or listed approved equivalent

Rack bonding conductor (RBC)	a) Shall be copper and may be insulated. b) Shall be listed for the application when insulated. c) Shall be sized as a No. 6 AWG (As a minimum).	a) Harger b) Or listed approved equivalent
Rack grounding-bonding busbar (RGB-RBB)	Grounding Strip for 2-post and 4-post Communications Racks. a) Shall be wrought copper and tin plated. b) Shall be capable of supporting multiple unit bonding conductors. c) Shall be listed.	a) Harger b) Panduit, Grounding Strip Kit, RGS134-1Y c) Or listed approved equivalent.
General bonding conductors or jumpers	Provide and install general bonding conductors and jumpers per construction documents. Refer to drawings and execution section for required locations. a) For all conductors and jumpers connecting equipment located in the same room as the b) TMGB-PBB/TGB-SBB, conductors/jumpers shall be in a green insulated jacket. This jacket shall include markings that indicate conductor size (minimum of #6 AWG), manufacturer, and UL listing.	a) Harger b) Panduit c) Or listed approved equivalent.
Bonding accessories – Grounding lugs	a) Shall be listed for the application and intended function. b) Shall be two-holed irreversible compression-crimp, with inspection window, exothermic weld or other irreversible listed approved application. c) Shall be copper or tin platted copper.	a) Erico, Cadweld Telecom Lugs b) Harger c) Panduit d) Or listed approved equivalent.
Bonding accessories – Unit bonding conductor (UBC)	a) Shall be listed for the application, intended function or use. b) Shall be a minimum No. 12 AWG. c) Shall be copper with 90-degree bent lugs installed.	a) Erico, Cadweld Telecom Lugs b) Harger c) Panduit d) Or listed approved equivalent.
Wire	Use #4 and #6 AWG wire suitable for grounding application.	
Connections	Make all bonding/grounding connections with irreversible compression/crimping or Exothermic/CAD weld connections with appropriate listed materials and hardware.	
Terminals	Terminals shall be solderless compression type, copper long-barrel NEMA two bolt.	

9.2 Firestopping

A. Any listed, UL/ASTM tested and approved application may be used if it complies with all local zoning, IBC/ICC (Building Codes), DCRA-DCMR and NEC-NFPA code requirements to re-establish all wall/floor membrane penetrations, ICT pathways and spaces back to its original fire rating or better (F, T, L, W or S ratings if applicable).

B. Firestopping material must conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted testing agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of actual field conditions.

Material	Requirements	Acceptable Manufacturers
General	Any listed, UL/ASTM tested and approved application may be used if it complies with all local zoning, IBC/ICC (Building Codes), DCRA-DCMR and NEC-NFPA code requirements to re-establish all wall/floor membrane penetrations, ICT pathways and spaces back to its original fire rating or better (F, T, L, W or S ratings if applicable).	Specified Technologies Inc. (STI), techserv@stifirestop.com www.stifirestop.com
Firestop Sealant	Single component latex formulations that upon cure do not re-emulsify during exposure to moisture.	STI SpecSeal® Series SSS Sealant STI SpecSeal® Series LCI Sealant
Firestop Putty	Intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers or silicone compounds.	STI SpecSeal® Series SSP Putty
Firestop Pillows	Re-enterable, non-curing, mineral fiber core encapsulated on six sides with intumescent coating contained in a flame-retardant poly bag.	STI SpecSeal® Series SSB Pillows.
Fire-Rated Cable Grommet	May be used as an alternate to a fire-rated or non-rated cable pathway device for single low voltage cables (up to 0.27 in. (7 mm) O.D) penetrating one or two-hour, gypsum board/stud wall assemblies or non-rated assemblies, either as a through penetration or as a membrane-penetration. a) Molded, two-piece, plenum-rated with an integral fire and smoke sealing foam membrane for sealing individual cable penetrations through framed wall assemblies. b) Capable of locking into place to secure the cable penetration within the wall assembly. c) Use only UL Classified grommet tested to requirements of ASTM E814 (UL1479) and CAN/ULC S115.	STI EZ-Firestop™ Grommets
Fire Rated Cable Pathways	Device modules comprised of steel pathway with self-adjusting intumescent foam pads allowing 0 to 100 percent cable fill.	STI EZ-PATH® Fire-Rated Pathway
Smoke and Acoustical Pathways	Device module comprised of a nonmetallic pathway with integral self-adjusting smoke and sound sealing system for cable penetrations through non-fire resistance rated wall or floor assemblies.	STI EZ-PATH® Smoke & Acoustical Pathway; Model No. NEZ33 or NEZ33CK

9.3 Conduit, Sleeve, Raceway, and Outlet Box Products

A. Materials shall consist of conduit, surface metal raceway, outlet boxes, fittings, enclosures; pull boxes, and other raceway incidentals and accessories as necessary for inside plant.

Component	Requirements	Acceptable Manufacturers
Conduit – EMT	1" minimum conduit size. Flexible Metal Conduit (FMC) is not acceptable. a) Conduit: Galvanized steel tubing shall meet ANSI C80.3. b) Couplings: Steel, cast iron, or malleable iron compression type employing a split, corrugated ring and tightening nut, with integral bushings and locknuts.	
Conduit – RMC	a) 1" minimum conduit size. b) Conduit: Hot dipped galvanized steel with threaded ends meeting ANSI C80.1. c) Couplings: Unsplit, NPT threaded steel cylinders with galvanizing equal to the conduit. d) Nipples: Same as conduit, up to 8" in diameter, with no running threads.	
Sleeves	a) ENT conduit, insulated throat bushings on each end.	
Surface Raceway	a) Two-piece, steel, single channel surface raceway.	Wiremold V2400 series or equivalent
Outlet Boxes	a) Shall be at least 4" (100 mm) x 4" (100 mm) x 2 ¼ "(57 mm). This size will provide accommodations for one or two 1" conduits. b) If a larger conduit is specified, the outlet box size shall be increased accordingly. A maximum 1 ¼" conduit will require a 4 11/16 "(120 mm) x 4 11/16 "(120 mm) x 2½" (64 mm) outlet box.	
Pull Strings	a) Plastic or nylon with a minimum test rating of 200 lb.	

9.4 Cable Trays

A. Materials consist of tray sections, tray fittings, connectors, supports, expansion joints, barrier strips, radius drops, bonding conductors and other incidentals and accessories as required for a complete, permanent cable tray Infrastructure. Provide all incidental and or miscellaneous hardware not explicitly shown in the Contract Documents but required for a fully operational system.

B. Physically verify existing site conditions prior to purchase and delivery of materials.

C. Cable tray components must be manufactured by a single manufacturer. Components shall not be intermixed between different manufacturers.
D. For a given manufacturer, all components shall be part of a single cable tray product line components shall not be intermixed between a manufacturer's cable tray product line.

Component	Requirement
Welded Wire	Cable tray shall be constructed of a welded wire mesh (high strength steel wires) with a continuous safety edge wire lip. Cable tray shall be complete with all tray supports, materials, and supplementary and miscellaneous hardware required for a complete cable tray system. a) Finish: Carbon steel with electro-plated zinc galvanized. b) Width shall be as shown in the Contract Documents. Where cable tray width is not shown in the Contract Documents, it shall be sized per the amount of cable to be placed in the trays (as shown in Contract Documents) plus an additional 20 percent for future expansion. c) Depth: minimum 2". d) Mesh: 2" x 4". e) Fittings shall be field fabricated from straight sections using manufacturer-approved tools and in accordance with manufacturer's instructions.
Grounding and Bonding	Per ANSI/NFPA 70 Section 318-7, cable tray shall be complete with bolted splicing hardware for grounding/bonding throughout the entire cable tray system.

9.5 Underground Ducts and Raceways

Component	Sub-Component	Requirements
Trenching and Backfill	Trenching and Excavation Backfill	Select as specified in CSI MasterFormat Division 270500 Section 02221.
	Concrete Slurry	Select as specified in CSI MasterFormat Division 270500 Section 02221.
	Concrete Pavement	Select as specified in CSI MasterFormat Division 270500 Section 02520.
	Asphalt Pavement	Select as specified in in CSI MasterFormat Division 270500 Section 02513.
Conduit System	Non-Metallic Conduit	a) PVC plastic pipe, ASTM D1785, Schedule 40 or 80, Type PVC 1120 b) 4" 45 Degree Fiberglass Bend: FRE Composite Inc., 30-4032 Elbow IPS c) 4" 90 Degree Fiberglass Bend: FRE Composite Inc., 30-4030 Elbow IPS
	Metallic Conduit	GRC with PVC coating (for building entrances, offsets and sweep bends) within 50 feet of the building protection.

	Conduit Joint Couplings	a) PVC non-metallic fittings must be installed with solvent applied couplings. b) Approved transition couplings shall be used to connect metal to plastic (PVC) conduits. c) Couplings shall be threaded and/or glued to provide a watertight seal at conduit junctions.
	Outside Pull-Box	Minimum 14-gauge galvanized steel with weatherproof locking cover and hardware surface mounting as specified in the contract. Dimensions as specified in the contract. Pullboxes shall have no more than one (1) conduit entering and one (1) conduit exiting the box.
Cable Routing Hardware	Cable Rack with Support Hardware	As required.
	Cable Rack Steps/Hooks	

9.6 Equipment and Telecommunications Rooms – Rack, Power, and Lighting

A. Contractors shall provide all items except equipment rack.

Component	Requirements	Acceptable Manufacturers
Equipment Rack – General	Racks shall: a) Be provided for the telecommunication system. b) Be upright, floor standing, steel. c) Conform to TIA-EIA Standard RS-310C for 19” or 23” x 84” racks. d) Be capable of supporting up to 600 pounds, with Type B universal mounting rail hole pattern. e) Be complete with all mounting hardware. Blank off unused rack space with matching steel panels if RUs are allocated for OCTO network devices/hardware.	CPI Newton Hubbell Ortronics Other UL/ASTM Listed Applications
Equipment Rack Mounting	Bond all OCTO infrastructures, pathways and spaces back to a bonding/grounding source as required in the current applicable NEC-NFPA-70 edition within the District of Columbia. a) Mount racks on an isolation pad and utilize non-conductive washers with appropriately sized lag screws to secure the rack to the floor. b) Secure racks to the floor with four screws per rack. c) Secure floor-mounted open racks from the top rail to the backboard in the room with a length of cable runway to prevent movement. d) Bond all racks to the isolated bonding bar within the TR and MC using a standard ground lug and #6 AWG jacketed green cable per the 007 portion of ANSI/TIA Standards 607-D Best Practices unless otherwise required by NEC-NFPA-70. e) Provide ground/bonding lug kit for data rack bonding.	Chatsworth #10605-019 rack/floor isolation kit or equivalent

Equipment Rack Cable Management	a) Provide horizontal and vertical cable management organizers as elsewhere specified in this section. b) Connect each TR to the ER. c) Provide a minimum of four rows of 5 count split front “D” ring horizontal cable management panels per rack.	CPI-Hubbell vertical cable managements for all OCTO ICT spaces – Hubbell VC76H
Racks and Supporting Fixtures		Newton Instrument Company or approved equivalent.
Ladder Rack	a) Use a 12” ladder rack or basket tray for all horizontal bulk cable management within TRs. b) Install 2” x 6” x 10” wire mesh cable tray in ceiling and TRs where deemed necessary to facilitate proper cable management. Contractor has the option to provide j-hooks or mesh cable tray for cable supports for distributing cables through the building. Contractor shall provide only cable tray in each ER and TR for cable support. c) Install cable management system at locations specified. Installation requires coordination with other trades. Bring any major corrections of the path to the attention of the Owner and the Engineer.	Cablofil CF105 Series, Hubbell 12” (w) Steel, 9" Ladder Series, or approved listed equivalent.
Wire Management Rings	a) Provide wall-mounted, split-front “D”-type wire management rings above, below, and between each wall-mounted termination panel.	
J-Hooks	a) Provide necessary quantity of 2” or larger J-shaped hooks with rolled edges, gray baked-enamel finish; complete with necessary hardware for attachment to sidewall, ceiling, or joist. b) Use J-hooks to support voice and data cable above suspended ceilings. c) Space J-hooks a maximum of 5 feet (recommended 3-5 feet).	
Cable Ties and Tie Wraps	a) Provide necessary quantify of Velcro-type cable ties for each system. Use Velcro-type cable ties exclusively for cable management within racks in TRs. b) If zip-tie wraps are required they shall meet the environmental space requirements for installation location per NEC-NPFA-70 Article #800.24: (Mechanical Execution of Work) i.e., Plenum Spaces.	
Plywood backboards	a) Provide 3/4” deep fire-retardant-treated plywood backboards. b) Plywood backboards shall conform to Product Standard PS1, Grade B-D, with one finish smooth side (Class/Grade A: exposed surface). c) Minimum size shall be 4 feet wide x 8 feet high.	
UPS	Provide one (1) UPS unit in each data equipment rack. The UPS system shall: a) Be line interactive design with a maximum transfer time of 4 milliseconds. b) Be a single conversion modular UPS System with SNMP Management Shall provide a minimum of 2000 VA of output power with 120 Volt input. c) Provide a minimum battery runtime of 20 minutes at full load.	

	d) Have a minimum of six NEMA 5-15R output receptacles. e) Be covered by a two-year on-site warranty. f) Have true sine-wave output waveform. g) Have front panel display indicating load level, battery charge level, and replacement battery indication. h) Be rack-mounted in the bottom of each 19" equipment rack. i) Provide grounding per ANSI/TIA-607-D requirements.	
Surge Protection	Surge protection devices shall have a 5 nanosecond or less response time for clipping excessive voltage. Devices shall: a) Consist of solid-state circuitry. b) Automatically reset after an operation with no degradation in protective capability. c) Have a light showing when the unit is operational. d) Be direct plug-in, plug strip, or hard-wired connection type as applicable to the respective component of equipment	
Lighting	Telecommunications Room (TR) lighting requirements: a) Install at least two light fixtures per room aligned to illuminate the front and the rear sides of the racked equipment that runs down the middle of the room. b) Electrical power for the lighting in a TR should not come from the same circuits as the telecommunication equipment. (Telecommunication equipment should be on dedicated circuits.) c) Locate light fixtures a minimum of 2.6m (8.5ft) above finished floor when possible and coordinate closely with the rack, cabinet, or enclosure placement. d) Coordinate the lighting layout with the equipment layout (especially overhead cable trays/ladder rack) to ensure that front and rear sides of equipment is well lit. e) Provide a minimum equivalent of 538lux (50 foot-candles) at the point of cable termination. 1. 1 lux = 1 lumen/m^2 2. 10.76 lux = 1 foot candle f) Use emergency lighting as required by applicable codes. Lighting should ensure that loss of power to normal lights will not hamper an emergency exit from the telecommunications space.	

9.7 Fiber Cable, Connectors, Patch Cords, and Terminating and Supporting Hardware

Component	Attribute	Requirements
Single-mode Fiber Optic Cable (OS1-OS2)	Features	a) All cables shall be factory-fabricated, low-loss, glass-type fiber optic single-mode step index cables with the following operational and construction features: 1. Reinforced with Aramid yarn for superior strength, for ISP fiber only no central strength member. 2. Color-coded PVC buffers for easy installation, yellow jacket. 3. Use for both vertical and horizontal applications in buildings. 4. UL® listed type of OFNR (riser) and OFNP (plenum). All cables shall conform to Articles #700-#800 NEC-NFPA-70. b) Where armored cable is required, cable shall be protected by flexible metal armor. c) Where indoor/outdoor cable is required, cable shall be specifically rated for indoor and outdoor use and shall include UV-resistant flame-retardant outer jacket and dry water blocking compound. Indoor/outdoor rated cables shall meet the environmental spaces they are being pulled through and placed into.
	Physical Specifications	Cladding Diameter: 125.0 +/- 0.7 µm Cladding Non-Circularity: <1.0% Colored Fiber Diameter: 250 +/- µm Core Diameter: 8.3 µm Core/Cladding Concentricity Error: 0.8 µm Minimum Proof Strength: 0.70 Gpa (100kpsi) Fiber Macrobend (100 turns, 75 mm diameter): 0.05dB @ 1310 nm/ 0.10dB @ 1550 nm Fiber Macrobend (1 turn @ 32 mm diameter): 0.5dB @ 1550 nm Coating Strip Force: 1.3 N <F < 8.9

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<tr>
<td></td>
<td>Optical Specifications</td>
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<tr><td>Index of Refraction:</td><td>0.37%</td></tr>
<tr><td>Mode Field Diameter</td><td>8.8 +/- 0.5 µm @1310 nm</td></tr>
<tr><td rowspan="4">Attenuation (maximum):</td><td>0.34 dB/km @ 1310 nm</td></tr>
<tr><td>0.31 dB/km @ 1383 nm</td></tr>
<tr><td>0.21 dB/km @ 1550 nm</td></tr>
<tr><td>0.24 dB/km @ 1625 nm</td></tr>
<tr><td>Attenuation at Water Peak:</td><td>2.0 dB/km @ 1385nm</td></tr>
<tr><td>Point Discontinuities:</td><td><=0.05 dB</td></tr>
<tr><td>Zero-Dispersion Wavelength:</td><td>1302 - 1322 10 nm</td></tr>
<tr><td>Zero Dispersion Slope:</td><td>0.092 ps/nm2-km</td></tr>
<tr><td>Fiber Polarization Mode Dispersion for Individual fiber (maximum):</td><td><= 0.2 ps/ √km</td></tr>
<tr><td>Cable Cutoff Wavelength</td><td><=1260 nm</td></tr>
</table>
</td>
</tr>
<tr>
<td>50µm Laser Optimized Multi-mode Fiber Optic Cable (OM-3/OM4+).</td>
<td>Features</td>
<td>
a) All optical fiber cables shall be factory-fabricated, low-loss, glass-type fiber optic multi-mode step index cables with the following operational and construction features:
1. Reinforced with Aramid yarn for superior strength, no central strength member.
2. Comply with ANSI/TIA-492A specifications and IS 11801 standards. Compliant with IEC 60793.
3. All OCTO-owned OFCP/OFCR cables shall be bonded back to a bonding/grounding source per NEC/NFPA-70 code requirements, Article #770.114.
4. Short Term: 340 lbs. Long Term: 170 lbs.
5. Have color-coded PVC to facilitate individual fiber identification and easy installation.
6. Have D-LUX® coating or approved equivalent to ensure color retention, minimize microbending losses and improve handling. Coating shall be mechanically strippable. Dual coating for excellent environmental performance and long-term reliability.
7. Have aqua color-coded cable jacket.
8. Used for both vertical and horizontal applications in buildings.
9. Shall have dual wavelength capability; transmitting at 850 and 1300nm ranges.
10. UL® listed type of OFNR (riser) and OFNP (plenum). All cables shall conform to Article 800 NEC.
11. Support 10 Gbps Ethernet applications to 300 meters or 1 Gbps to 1,000 meters.
12. Support legacy: Ethernet, Fast Ethernet, Token Ring, ATM, FDD.
b) Where armored cable is required, cable shall be protected by flexible metal armor.
c) Where indoor/outdoor cable is required, cable shall be specifically rated for indoor and outdoor use and shall include UV-resistant flame-retardant outer jacket and dry water blocking compound.
</td>
</tr>
</table>

<table>
<tr><td></td><td>Physical Specifications</td><td>Cladding Diameter: 50 µm +/-3 µm
Core/Cladding Concentricity Error: <=1.5 µm
Cladding Non-Circularity: <2.0%
Coating Diameter (uncolored): 245 +/- 10 µm
Proof Test Levels: 0.7 Gpa minimum
Operating Temperature Range: -60 degrees C to 85 degrees C
Core Non-Circularity: <=5%
Cladding Diameter: 125 µm +/- 2 µm
Colored Fiber Diameter: 250 +/- 15 µm
Coating/Cladding Concentricity Error: +/- 8 µm
Minimum Tensile Strength: 100,000 psi</td></tr>
<tr><td></td><td>Optical Specifications</td><td><table>
<tr><td>Maximum Attenuation:</td><td>2.4 dB/km at 850 nm
0.7 dB/km at 1300 nm</td></tr>
<tr><td>Minimum Bandwidth:</td><td>3500 MHz-km at 850 nm
(overfilled)
500 MHz-km at 1310 nm
(overfilled)
4700 MHz-km at 850 nm
(laser)
500 MHz-km at 1300 nm
(laser)</td></tr>
<tr><td>Numerical Aperture:</td><td>0.200 + 0.015</td></tr>
<tr><td>Nominal Refraction Index Difference bw Peak of Core and Cladding:</td><td>1.00%</td></tr>
<tr><td>Effective Group Index of Refraction @ 850 nm:</td><td>1.483</td></tr>
<tr><td>Effective Group Index of Refraction @1300 nm:</td><td>1.479</td></tr>
<tr><td>Point Discontinuities @ 850 nm and 1300 nm:</td><td><=0.2 dB</td></tr>
</table></td></tr>
<tr><td></td><td>LC-duplex – General Requirements</td><td>a) All single-mode cables are to be terminated with LC-duplex type connectors at each end of each strand unless specified otherwise.
b) Contractor shall provide all consumable and incidental material required for proper termination of all fiber optic connectors.</td></tr>
<tr><td>Single-mode Connectors</td><td>LC-duplex - Features</td><td>Single-mode LC connectors must have the following features:
a) Connectors shall be on factory pre-terminated pigtails which shall be fusion spliced to the individual fiber strand.
b) LC connectors shall meet ANSI/TIA-568-D/E.3 standard and are duplexable.</td></tr>
</table>

	LC-duplex - Specifications	**Parameter** / **Singlemode** Insertion Loss: 6.10 dB typical Return Loss: <- 20 dB Durability: 500 rematings, <0.30 dBchange Temperature Cycling: <0.30 dB Change Material: Ferrule Tip: Ceramic; Housing: Thermoplastic Average Loss: 0.2 dB, standard deviation 0.1 dB
	SC - General Requirements	a) Contractor shall provide all consumable and incidental material required for proper termination of all fiber optic connectors. b) Where required for the Distributed Antenna System (DAS), SC Angled Polished Connectors (APC) shall be used.
	SC - Features	Where required for use, Single-mode SC connectors must have the following features: a) Connectors shall be on factory pre-terminated pigtails which shall be fusion spliced to the individual fiber strand. b) Connectors shall meet ANSI/TIA-568-D/E.3 standard and are duplexable. c) New one-step crimp ring with jacket retention.
	SC - Specifications	**Parameter** / **Singlemode** Insertion Loss: 0.15 dB typical Reflectance: <- 40 dB for Super PC Durability: 1000 rematings, <0.20 dBchange Tensile Strength: 20 lb, <0.20 dB change Temperature Cycling: -40o C to + 80oC, 40 cycles, <0.30 dB change Material: Ferrule Tip: Zirconia; Housing: Thermoplastic
	LC - General Requirements	a) All multi-mode cables are to be terminated with LC-duplex type connectors at each end of each strand unless specified otherwise. b) Contractor shall provide all consumable and incidental material required for proper termination of all fiber optic connectors.
Multi-mode Connectors	LC - Features	Multi-mode LC connectors must have the following features: a) Connectors shall be on factory pre-terminated pigtails which shall be fusion spliced to the individual fiber strand. c) LC connectors shall meet ANSI/TIA-568-D/E.3 standard and are duplexable.

	LC - Specifications	**Parameters** / **Multimode** Interconnection: LC connectors Compatability: Insertion Loss: Composite ferrule: 0.5 dB typical; Standard ceramic ferrule: 0.3 dB typical Durability: 1000 rematings <0.20 dB change Tensile Strength: 20 lb, ≤ 0.20 dB change Temprature Cycling: -40o C to + 80oC, 40 cycles, <0.30 dB change Material: Ferrule: Preradiused Zirconia; Housing: Thermoplastic
	SC - General Requirements	Contractor shall provide all consumable and incidental material required for proper termination of all fiber optic connectors.
	SC - Features	Where required for use, SC connectors shall have the following features: Connectors shall be on factory pre-terminated pigtails which shall be fusion spliced to the individual fiber strand.
	SC - Specifications	**Parameter** / **Multimode** Interconnection: SC connectors Compatability: Insertion Loss: Composite ferrule: 0.5 dB typical; Standard ceramic ferrule: 0.3 dB typical Durability: 1000 rematings,< 0.20 dBchange Tensile Strength: 20 lb, ≤ 0.20 dB change Temperature Cycling: -40o C to + 80oC, 40 cycles, <0.30 dB change Material: Ferrule: Preradiused Zirconia; Housing: Thermoplastic
	General	Contractor shall provide and install fiber optic patch panels as indicated on drawings.
Termination Hardware	144 port fiber optic fiber termination shelves	Shall have the following features: a) 144 Port b) 4 RU height max c) 19” rack mountable d) Front loading panels e) Fully loaded with bulkheads as required f) Comply with ANSI/TIA-606-C labeling g) Front cable management rings
	48 port fiber optic fiber termination shelves	a) 48 port b) 1 RU height Maximum c) 19” rack mountable d) Front loading panels

		e) Fully loaded bulkheads as required f) Comply with ANSI/TIA-606-C labeling g) Front cable management rings for patch cord slack
Patch Cords		a) Provide patch cords to the DC-Net Project manager when required for DC-Net installation of network and/or workstation equipment. b) All patch cords shall be factory fabricated. c) All patch cords shall be the recommended series intended by the manufacturer to integrate with the installed cable segments and termination hardware. d) All patch cords shall be manufactured by the same vendors as the optical fiber cable and hardware. e) Provide patch cords in the quantities indicated in the drawings. Provide a schedule of all cords indicating the planned lengths, quantities and colors to DC-Net for approval prior to placing any orders for cords. f) Patch color codes are determined by their fiber type: OM3 cable shall be aqua colored. OS1-OS2 shall be yellow. g) Excessive patch cord lengths are not permitted. All patch cords shall be appropriately sized while maintaining proper cable bend radius.
Supporting Hardware		a) Use only the manufacturer's approved cable supporting hardware such as split mesh support grips (Kellum grips) or messenger wire approved for use. b) Messenger Wire shall be rated such that the planned installation weight of the cabling shall not exceed 60% of the rated breaking strength.

9.8 Category 6 Cabling, Outlets, and Patch Panels

Component	Attribute	Requirements
Category 6 UTP Cable	General	a) Provide all installation materials and consumables including straps, mounting hardware, hangers, fire stop material, labels, etc. b) All cable shall consist of a 4-pair, 23/24 gauge solid conductor UTP and shall terminate on 8-pin modular jacks at each information outlet. c) All cable jacket material shall conform to article 800 NEC for use as plenum or non-plenum cables. Cables shall be UL® type CMP (plenum), CMR (riser) or type CM (general) as appropriate. All cables running in raised floor space shall be plenum rated. d) All cable shall be tested and guaranteed to meet or exceed the requirements for Cat 6 performance as defined in ANSI/TIA-568-D/E.2 and be part of the UL® LAN certification and follow-up program. e) Plenum shall be plenum rated and meet applicable requirements of ANSI/ICEA S-80- 576 for plenum. All four pairs must be insulated with F.E.P. No constructions that use mixed insulation materials will be allowed. f) Cable intended for use in data applications including but not limited to 100Base-T, 1000Base-T, and 1000Base-TX.
	Electrical	Shall have the following electrical requirements per ASTM D4566:

		a) Resistance <=9.38 ohms per 100m at 20ºC b) Resistance unbalance between 2 conductors of any pair <=5% at 20ºC c) Capacitance @1 kHz @20ºC <=330 pF/100m d) Characteristic impedance 100 ohms + 15% from 1MHz to highest referenced frequency.
	Physical	a) Consist of four (4) 23/24 AWG twisted pairs. b) Be suitable for the environment in which they are to be installed. c) Overall diameter of the cable less than 0.25 inches. d) Withstand a bend radius of 4 times the cable diameter at e) -20ºC without damage to jacket or insulation and shall have min. ultimate breaking strength of 90 lb./ft.
Telecom Outlets (TO)	General	a) Meet or exceed NEXT and all other Category 6 transmission performance requirements for connecting hardware, as specified in ANSI/TIA-568-D/E.2 Commercial Building Telecommunications Cabling Standard and be part of the UL® LAN Certification and Follow-up program. b) Capable of being utilized in a modular patching situation or as a modular TO supporting all intended data applications including but not limited to 100Base-T, 1000Base-T, and 1000Base-TX.
	Faceplates	a) UL® listed and CSA certified. b) Constructed of high-impact, ABS plastic UL® 94V-0 construction (except where noted otherwise). c) Available in a variety of colors to match other utilities or raceways installed. d) Possess recessed designation windows to facilitate labeling and identification. e) Include a clear plastic cover to protect labels in the designation window. f) Have mounting screws located under recessed designation windows. g) Comply with ANSI/TIA-606-C labeling specifications. h) Have a blank cover on all unused ports.
Termination Hardware	Patch panel	a) Shall be high density such that 24-ports occupy one rack unit and 48 ports occupy two rack units. b) Shall use Cat 6+ RJ45 jacks in 6- or 8-port modules. c) Shall have rear-mounted cable management bar to ensure proper bend radius and strain relief for cabling. d) Shall accept color-coded identification tabs and port protecting shutters. e) Shall comply with ANSI/TIA-606-C/D labeling specifications. f) Jack (UMJ 8 position/8 conductor) shall terminate to a 110D-type insulation displacement contact, printed circuit board, to lead frame mounted connector. g) Jack shall be universal modular jack, 8 position, un-keyed unless noted otherwise. h) Jack shall support termination of 22, 24 and 26 AWG solid conductor, four pair, unshielded twisted pair copper cable.

9.9 Cabling, Patch Panels, and Supporting Hardware

Component	Requirements
Cable – Multi-Pair Category 3, 24 AWG	For Analog voice services only. a) Cable shall be available in 100, 200, and 300 pair counts. b) Cable shall be conformance tested to meet ANSI/TIA-568-D.2 for category 3 cables. c) Where 300 pair cables are specified, three 100-pair cables of equal quality may be substituted. d) Pairs shall be color-coded per ANSI/ICEA S-80-576. e) Cables with more than 25 pairs are to be assembled with sub-units of 25 pair and have continuous color-coded binders. f) The core shall be overlaid with a corrugated aluminum sheath, which is bonded to an outer jacket of PVC plastic to form an alvyn sheath. g) The PVC sheath shall have improved frictional properties, allowing the cable to be installed in conduit without the use of pulling lubricants. h) Cable jacket material shall conform to Article 800 NEC for use as non-plenum cables. Cables shall be UL® type CMR (riser) and/or UL® listed for fire safety. i) Armored cable shall be in a flexible metal jacket for crush resistance.
Cable - 25-Pair Category 3, 24 AWG	For Analog voice services only. a) Cable shall be comprised of 24 AWG twisted pair copper conductors individually insulated with PVC and sheathed in a riser rated thermoplastic outer jacket. b) Pairs shall be color coded in accordance with ANSI/ICEA S-80-576. c) Cable jacket material shall conform to Article 800 NEC for use as plenum or non- plenum cables. Cables shall be UL® type CMR (riser) and/or UL® listed for fire safety. d) Cable shall meet or exceed ANSI/TIA-568-D.2 for category 3 compliance.
Patch Panel	a) Shall be high density such that 24-ports occupy one rack unit and 48 ports occupy two rack units. b) Shall use Category 6+ RJ45 jacks in 6- or 8-port modules. c) Shall have rear-mounted cable management bar to ensure proper bend radius and strain relief for cabling. d) Shall accept color-coded identification tabs and port protecting shutters. e) Shall comply with ANSI/TIA-606-C/D labeling specifications. f) Jack (UMJ 8 position/8 conductor) shall terminate to a 110D-type insulation displacement contact, printed circuit board, to lead frame mounted connector. g) Jack shall be universal modular jack, 8 position, un-keyed unless noted otherwise. h) Jack shall support termination of 22, 24 and 26 AWG solid conductor, four pair, unshielded twisted pair copper cable. i) Angled patch panels are preferred, but not required.
Supporting Hardware	a) Use only manufacturer's approved cable supporting hardware such as split mesh support grips (Kellum grips) or messenger wire approved for use. b) Messenger wire shall be rated such that the planned installation weight of the cabling shall not exceed 60 percent of the rated breaking strength.

9.10Voice Backbone Cabling

Component	Attribute	Requirements
Voice Backbone	General	a) Use unshielded 24 AWG multi-pair copper cables as the vertical riser cables to connect TRs to the ER. Cable shall support voice and low speed data. b) Observe bending radius and pulling strength requirements of all backbone cables during handling and installation. Multi-pair copper cables shall be in non-plenum form and placed in conduit as required. c) Cable shall consist of solid-copper conductors insulated with expanded polyethylene covered by a Plenum-Rated skin, be conformance tested to meet ANSI/EIA-568A for Cat6 cables, be UL7 Listed as CMP. d) Cable shall be available in 25 pair counts. UL7 Listed for Fire Safety. ISO 9001 Certified Manufacturer.
	Electrical Specifications	a) Average DC Resistance: 26.5Ω/1,000 ft (8.7Ω/100m), maximum b) Average DC Resistance Unbalance: 1.7%, maximum c) Mutual Capacitance @ 1kHz: 16 nF/1000 ft (5.25 nF/100 m), maximum d) Capacitance Unbalance (pair to ground): 201pF/1,000 ft (65.94 pF/100m) maximum
	Attenuation (dB/100 m)	Frequency Attenuation (Max.) a) 1.00 MHz 2.3 dB b) 5.00 MHz 4.9 dB c) 10.00 MHz 8.5 dB d) 16.00 MHz 12 dB
	Near-End Crosstalk	Frequency Pair-to-Pair NEXT (Max.) a) 1.00 MHz 13.8 dB b) 4.00 MHz 11.2 dB c) 10.00 MHz 10.2 dB d) 16.00 MHz 9.2 dB

9.11Testing Equipment

Component	Requirements	Acceptable Manufacturers
Fiber and Copper Test Sets	Specifically rated for the cabling being tested, properly configured, and calibrated per manufacturer's requirements.	Fluke, Agilent Technologies, or an engineer approved equivalent.

10 Codes and Standards

10.1General

All design, installation, testing, modification, and removal of telecommunications cabling networks shall be done per manufacturer's requirements according to National Electrical Code (NEC-NFPA-70 2011Edition) as required by the DCRA-DCMR, IEEE C.2 2017/NESC National Electrical Safety Code, state codes, local codes, requirements of authorities having jurisdiction and the following standards and publications:

1. DCRA-DCMR construction and fire codes
2. CSI MasterFormat
3. Occupational Safety and Health Act and Occupational Safety and Health Administration (OSHA) construction regulations and standards
4. American National Standards Institute/Telecommunications Industry Association (ANSI/TIA)
    a. ANSI/TIA-526-7 – Measurement of Optical Power Loss of installed Single-mode Fiber Plant Cable
    b. ANSI/TIA-758-B – Customer Owned Outside Plant Telecommunications Cabling Standard
    c. ANSI/TIA-942-B – Telecommunications Infrastructure Standard for Data Centers
5. American Society for Testing Materials International (ASTM)
    a. A653 – Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process, Structural (Physical) Quality
    b. A123 – Specification for Zinc (Hot Galvanized) Coatings on products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
    c. A1011 – Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with improved Formability
    d. A1008 – Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy Formability
    e. ASTM B633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel
6. National Electrical Manufacturers Association
    a. NEMA VE 1 – Metallic Cable Tray Systems
    b. NEMA VE 2 – Cable Tray Installation Guidelines

7. Applicable publications: BICSI Technical Manuals
    a. BICSI Information Technology Systems Installations Methods Manual
    b. BICSI Telecommunications Distribution Methods Manual (TDMM)
    c. BICSI Outside Plant Design Reference Manual (OSPDRM)
    d. ANSI/BICSI Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices
    e. ANSI/BICSI Information and Communication Technology Systems Design and Implementation Best Practices for Educational Institutions and Facilities

10.2 Firestopping

1. DCRA-DCMR fire codes – fire detection, prevention, compartmentalization, and containment systems and assemblies
2. ANSI/TIA-1179-2010 "Healthcare Facility Telecommunications Infrastructure Standard"
3. ANSI/TIA-569-E "Commercial Building Standard for Pathways and Spaces"
4. ANSI/UL1479, "Fire Tests of Through Penetration Firestops"
5. ASTM E814, "Fire Tests of Through Penetration Firestops"
6. ASTM E90, "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"
7. International Code Council (ICC) International Building Codes
8. National Fire Protection Agency (NFPA)
    a. NFPA 101: Life Safety Code
    b. NFPA 70: National Electrical Code (NEC-NFPA-70 2011Edition)
    c. NFPA 72: National Fire Alarm and Signaling Code
9. Underwriters Laboratories Inc. (UL) – Fire Resistance Directory

10.3 Communications

1. ANSI/TIA-568-D/E.0-D/E.4: Commercial Building Telecommunications Cabling Standard
2. ANSI/TIA-569-E: Commercial Building Standard for Telecommunication Pathways and Spaces
3. ANSI/TIA-606-C: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications

5. ISO/IEC IS 11801: Generic Cabling for Customer Premises
6. Applicable publications
    a. BICSI ITSIMM: Telecommunications Cabling Installation Manual
    b. BICSI TDMM – latest edition applies
    c. BICSI OSPDRM – latest edition applies

10.4Equipment Room Fittings

1. ANSI/NFPA 70 – National Electrical Code (NEC) Articles 250, 300 and 645
2. ANSI/TIA-568-D/E.0- Generic Telecommunications Cabling Standard
3. ANSI/TIA-568-D/E.1- Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA-568-D/E.2- Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted-Pair Cabling Components, including applicable addendum.
5. ANSI/TIA-568- D/E.3 – Optical Fiber Cabling Components Standard
6. ANSI/TIA-569- E – Commercial Building Standard for Telecommunications Pathways and Spaces
7. ANSI/TIA -604 Series – Fiber Optic Connector Intermateability Standards
8. ANSI/TIA-606-C – Administration Standard for Telecommunications Infrastructure of Commercial Buildings
9. ANSI/TIA-607-D – Commercial Building Grounding and Bonding Requirements for Telecommunications
10. FCC CFR 47 Part 68 – Connection of Terminal Equipment to the Telephone Network
11. Applicable publications
    a. BICSI TDMM – latest edition applies

10.5Underground Ducts and Raceways

1. ANSI-C80.2 Specification for Rigid Steel Conduit, Enameled
2. ANSI/TIA-569-E Commercial Building Standard for Telecommunications Pathway and Spaces
3. ANSI/TIA-607-D Commercial Building Grounding and Bonding Requirements for Telecommunications
4. ANSI/TIA-758-B/C Customer Owned Outside Plant Telecommunications Cabling Standard
5. IEEE C.2 2017/NESC
6. NFPA National Electrical Code (NEC-NFPA-70 2011Edition)

7. NEMA
    a. RN1, PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
    b. TC3, PVC Fittings for use with Rigid PVC Conduit and Tubing
    c. TC6, PVC and ABS Plastic Utilities Duct for Underground Installation
    d. TC8, Extra Strength PVC Plastic Utilities Duct for Underground Installation
    e. TC9, Fitting for ABS and OVC Plastic Communications Duct and Fittings for Underground Installation
    f. TC10, PVC and ABS Plastic Communications Duct and Fittings for Underground Installation
8. UL Standards
    a. UL 6 Rigid Metal Electrical Conduit
    b. UL 651 Schedule 40 and 80 PVC Conduit
9. Applicable publications
    a. BICSI TDMM – latest edition applies
    b. BICSI OSPDRM – latest edition applies

10.6Communications Backbone Cabling

1. DCRA-DCMR
2. NFPA National Electrical Code (NEC-NFPA-70 2011Edition)
3. ANSI/TIA:
    a. ANSI/TIA-568-D/E.1 -Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements
    b. ANSI/TIA-568-D/E.3 -Commercial Building Telecommunications Cabling Standard, Part 3 Optical Fiber Cabling Components Standard
    c. TIA-569-D - Commercial Building Standard for Telecommunications Pathways and Spaces
    d. ANSI/TIA-606-C - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
    e. ANSI/TIA-607-D - Commercial Building Grounding Earthing and Bonding Requirements for Telecommunications
    f. ANSI/TIA-526-7 - Measurement of Optical Power Loss of installed Single-mode Fiber Plant Cable
    g. ANSI/TIA-526-14A - Optical Power Loss Measurements of installed Multi-mode Fiber Cable Plant
    h. ANSI/TIA-758-B - Customer Owned Outside Plant Telecommunications Cabling Standard
    i. ANSI/TIA-568-B-2001 - Optical Fiber Cable Color Coding
    j. ANSI/TIA-942-B - Telecommunications Infrastructure Standard for Data Centers
4. UL® for wiring:

   a. UL® Standard 910 “Test method for fire and smoke characteristics of cable used in air handling spaces.” Provide products that are UL® listed and labeled for such use.
   b. UL® testing bulletin.
   c. UL® cable certification and follow up program.
   d. UL® Standard 1666 “Test for Flame Propagation Height of Electrical and Optical- Fiber Cables Installed Vertically in Shafts.”
5. ASTM
6. NEMA
7. ANSI/NECA/BICSI 568-2006 Standard for Installing Commercial Building Telecommunications Cabling or latest edition
8. Institute of Electrical and Electronic Engineers (IEEE): 802.3, 802.11, C.2 2017-2020

10.7Horizontal Cabling

1. DCRA-DCMR
2. NFPA National Electrical Code (NEC-NFPA-70 2011Edition)
3. UL® for wiring:
   a. UL® Standard 910 Test method for fire and smoke characteristics of cable used in air handling spaces. Provide products that are UL® listed and labeled for such use. UL® testing bulletin. Underwriters Laboratories (UL®) cable certification and follow up program.
4. ANSI/TIA
   b. ANSI/TIA-568-D/E.1 - Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
   c. ANSI/TIA-568-D/E.2 - Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
   d. TIA-569-E - Commercial Building Standard for Telecommunications Pathways and Spaces
   e. ANSI/TIA-606-C - Administration Standard for Commercial Telecommunications Infrastructure
   f. ANSI-J-STD-607-D - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   g. ANSI/TIA-862 - Building Automation Systems Cabling Standard for Commercial Buildings
   h. ANSI/TIA-942-B - Telecommunications Standard for Data Centers
5. NEMA
6. NECA/BICSI 568-2006 Standard for Installing Commercial Building Telecommunications Cabling
7. ASTM

8. IEEE: 802.3, 802.11, C.2 2017-2020

10.8TIA Standards and Technical Service Bulletins

(Accessed 7/15/18)

The following table lists the current version of the TIA standards and Technical Service Bulletins managed by the TR-42 committee as of September 2017. This is a list of standards that have been published or in the process of being published. They are available through TIA or HIS (global.ihs.com). This list does not include new standards being developed or revisions to existing standards that have not been approved for publication.

Table 4: Current Revision of TIA Standards Available (Accessed July 16, 2018)

Document Number	Document Name	Date Published
ANSI/TIA-492AAAE (WBMMF)	DETAIL SPECIFICATION FOR 50-M CORE DIAMETER/125-M CLADDING DIAMETER CLASS 1A GRADED-INDEX MULTIMODE OPTICAL FIBERS WITH LASER-OPTIMIZED BANDWIDTH CHARACTERISTICS SPECIFIED FOR WAVELENGTH DIVISION MULTIPLEXING	06/16
ANSI/TIA-526-7-A	MEASUREMENT OF OPTICAL POWER LOSS OF INSTALLED SINGLE-MODE FIBER CABLE PLANT, ADOPTION OF IEC 61280-4-2 EDITION 2: FIBRE-OPTIC COMMUNICATIONS SUBSYSTEM TEST PROCEDURES – PART 4-2: INSTALLED CABLE PLANT – SINGLE-MODE ATTENUATION AND OPTICAL RETURN LOSS MEASUREMENT	07/29/2015
ANSI/TIA-526-14-C	OPTICAL POWER LOSS MEASUREMENT OF INSTALLED MULTIMODE FIBER CABLE PLANT; MODIFICATION OF IEC 61280-4-1 EDITION 2, FIBER-OPTIC COMMUNICATIONS SUBSYSTEM TEST PROCEDURES- PART 4-1: INSTALLED CABLE PLANT-MULTIMODE ATTENUATION MEASUREMENT	04/01/2015
ANSI/TIA-568.0-D/E	GENERIC TELECOMMUNICATIONS CABLING FOR CUSTOMER PREMISES	2019
ANSI/TIA-568.1-D/E	COMMERCIAL BUILDING TELECOMMUNICATIONS INFRASTRUCTURE STANDARD	2019
*ANSI/TIA-568-C.2	BALANCED TWISTED-PAIR TELECOMMUNICATIONS CABLING AND COMPONENTS STANDARDS	04/2010
ANSI/TIA-568-C.2-1 (category 8 Addendum)	BALANCED TWISTED-PAIR TELECOMMUNICATIONS CABLING AND COMPONENTS STANDARD, ADDENDUM 1: SPECIFICATIONS FOR 100CATEGORY 8 CABLING	06/30/2016
ANSI/TIA-568.3-D/E	OPTICAL FIBER CABLING COMPONENTS STANDARD	2019
ANSI/TIA-568.4-D/E	BROADBAND COAXIAL CABLING AND COMPONENTS STANDARD	2019
ANSI/TIA-569-E	TELECOMMUNICATIONS PATHWAYS AND SPACES	2019

ANSI/TIA-569-D-1	TELECOMMUNICATIONS PATHWAYS AND SPACES ADDENDUM 1, REVISED TEMPERATURE AND HUMIDITY REQUIREMENTS FOR TELECOMMUNICATIONS SPACES	10/21/16
ANSI/TIA-570-C	RESIDENTIAL TELECOMMUNICATIONS INFRASTRUCTURE STANDARD	08/16/12
ANSI/TIA-604-18	FOCIS 18 FIBER OPTIC CONNECTOR INTERMATEABILITY STANDARD - TYPE MPO- 16	11/23/2015
ANSI/TIA-606-C	ADMINISTRATION STANDARD FOR TELECOMMUNICATIONS INFRASTRUCTURE	6/19/17
ANSI/TIA-607-D	GENERIC TELECOMMUNICATIONS BONDING AND GROUNDING (EARTHING) FOR CUSTOMER PREMISES	2019
ANSI/TIA-607-C-1	GENERIC TELECOMMUNICATIONS BONDING AND GROUNDING (EARTHING) FOR CUSTOMER PREMISES ADDENDUM 1 – BONDING IN MULTI-TENANT BUILDINGS	01/2017
ANSI/TIA-758-B	CUSTOMER-OWNED OUTSIDE PLANT TELECOMMUNICATIONS INFRASTRUCTURE STANDARD	03/27/12
ANSI/TIA-862-B	BUILDING AUTOMATION SYSTEMS CABLING STANDARD	02/29/16
ANSI/TIA-862-B-1	BUILDING AUTOMATION SYSTEMS CABLING STANDARD ADDENDUM 1: UPDATED REFERENCES, ACCOMMODATION OF NEW MEDIA TYPES	09/17
ANSI/TIA-942-B	TELECOMMUNICATIONS INFRASTRUCTURE STANDARD FOR DATA CENTERS	07/12/17
ANSI/TIA-1005-A	TELECOMMUNICATIONS INFRASTRUCTURE STANDARD FOR INDUSTRIAL PREMISES	05/03/12
ANSI/TIA-1152-A	REQUIREMENTS FOR FIELD TEST INSTRUMENTS AND MEASUREMENTS FOR BALANCED TWISTED-PAIR CABLING	11/10/2016
ANSI/TIA-1179-A	HEALTHCARE FACILITY TELECOMMUNICATIONS INFRASTRUCTURE STANDARD	08/21/17
ANSI/TIA-1183-A (Mainly for manufacturer qualification)	MEASUREMENT METHODS AND TEST FIXTURES FOR BALUN-LESS MEASUREMENTS OF BALANCED COMPONENTS AND SYSTEMS, EXTENDING FREQUENCY CAPABILITIES TO 2 GHZ	02/2017
ANSI/TIA-4966	TELECOMMUNICATIONS INFRASTRUCTURE STANDARD FOR EDUCATIONAL FACILITIES	05/12/14
ANSI/TIA-4966-1	TELECOMMUNICATIONS INFRASTRUCTURE STANDARD FOR EDUCATIONAL FACILITIES ADDENDUM 1: UPDATED REFERENCES, ACCOMMODATION OF NEW MEDIA TYPES	09/17
ANSI/TIA-4994	STANDARD FOR SUSTAINABLE INFORMATION COMMUNICATIONS TECHNOLOGY	03/18/15
ANSI/TIA-5017	TELECOMMUNICATIONS PHYSICAL NETWORK SECURITY STANDARD	02/19/2016
ANSI/TIA-5048	AUTOMATED INFRASTRUCTURE MANAGEMENT (AIM) SYSTEMS- REQUIREMENTS, DATA EXCHANGE AND APPLICATIONS	06/22/2017
The following TIA Technical Service Bulletins (TSBs) provide guidance on installation and design best practices, mitigation techniques, etc. on a variety of topics.		

TIA TSB-155-A	GUIDELINES FOR THE ASSESSMENT AND MITIGATION OF INSTALLED CATEGORY 6 CABLING TO SUPPORT 10GBASE-T	10/01/2014
TIA TSB-162-A	TELECOMMUNICATIONS CABLING GUIDELINES FOR WIRELESS ACCESS POINTS	11/1/2013
TIA TSB-184-A	GUIDELINES FOR SUPPORTING POWER DELIVERY OVER BALANCED TWISTED-PAIR CABLING	02/2017
TIA TSB-185	ENVIRONMENTAL CLASSIFICATION (MICE) TUTORIAL	June 2017 (reaffirmed)
TIA TSB-190	GUIDELINES ON SHARED PATHWAYS AND SHARED SHEATHS	06/01/2011
TIA TSB-5018	STRUCTURED CABLING INFRASTRUCTURE GUIDELINES TO SUPPORT DISTRIBUTED ANTENNA SYSTEMS	06/2016
TIA TSB-5019	HIGH PERFORMANCE STRUCTURED CABLING USE CASES FOR DATA CENTERS AND OTHER PREMISES	04/01/2015
TIA TSB-5021	GUIDELINES FOR THE USE OF INSTALLED CATEGORY 5E AND CATEGORY 6 CABLING TO SUPPORT 2.5GBASE-T AND 5GBASE-T	01/01/2017

11 Terms and Definitions

ACEG – Alternating Current Equipment Ground

ADA – Americans with Disabilities Act

ADAAG – ADA Accessibility Guidelines

AHJ – Authority Having Jurisdiction – may include Fire Marshals, Architects, Structural Engineers and Professional Engineers

AIA – American Institute of Architects

ANSI – American National Standards Institute

APC – Angled Polished Connectors

ASTM – American Society for Testing Materials

ATR – Above using threaded rods

BCT or BTC – Bonding Telecommunications Conductor for Telecommunications: Conductor that interconnects the telecommunications bonding infrastructure to the building's service equipment (power) ground.

BD – Building Distributor

BICSI – Building Industry Consulting Services International

Bonding – Joining of metallic parts to form an electrically conductive path.

CD – Campus Distributor

CPVC – Chlorinated Polyvinyl Chloride

Conditioned – Spaces directly provided with heating and cooling.

Contractor – Person or team who will install, test, modify, or remove District government-owned or operated communications infrastructure or who is responsible for overseeing these tasks, such as District government employees, telecommunications contractors, or 3rd party vendors.

CSI – Construction Specifications Institute

DAS – Distributed Antenna System

DP – Demarcation Point: Provider Outside Plant (OSP) cable point of entry to the rack/cabinet termination point – at a panel or switch – commonly located in the basement.

EDP – Electrical Distribution Panel

EF – Entrance Facility

EDP – Electrical Distribution/Branch/Feeder Panels

EMI – Electromagnetic Interference

EMT – Electrical Metallic Tubing

ER – Equipment Room (MDF)

Finished Space – Space other than mechanical rooms, electrical rooms, furred spaces, pipe chases, and unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, tunnels, and interstitial spaces.

FMC – Flexible Metal Conduit

GE – Grounding Equalizer or Grounding/Earthing Electrode: Conductor that interconnects elements of the telecommunications grounding infrastructure.

GEC – Grounding Electrode Conductor

Ground – A conducting connection, whether intentional or accidental, between an electrical circuit (e.g., telecommunications) or equipment and the earth, or to some conducting body that serves in place of earth.

HVAC – Heating Ventilation and Air Conditioning

IC – Inter/Intra-Cross Connect (IDF)

IC-BD – Interconnecting Cross-Connect/Building Distributor

ICT – Information Communications Technology

ID – Interior diameter

IEEE – Institute of Electrical and Electronic Engineers

IMC – Intermediate Metal Conduit

Junction Box – Pullbox wherein a conduit run transitions from a feeder conduit to multiple distribution conduits.

MC – Main Cross-Connect

MC-CD – Main Cross Connect/Campus Distributor

NEC/NFPA – National Electrical Code/National Fire Protection Agency

NEMA – National Electrical Manufacturers Association

NESC – National Electrical Safety Code

NEXT – Near-End Crosstalk

NRTL – Nationally Recognized Testing Laboratory

OD – Outer diameter

OSHA – Occupational Safety and Health Administration/Act

OTDR – Optical Time Domain Reflectometry

PB – Polybutene

PBB – Primary Busbar: There is one (1) PBB allowed per building, located in the main ER or EF. This busbar is directly bonded to the electrical or building facility service ground.

Pullbox – Metallic box with a removable cover, used to assist pulling cable through conduit runs longer than 100’ or in which there are more than 180 degrees of bends.

PVC – Polyvinyl Chloride

Raceway – Any enclosed channel for routing wire, cable or busbars.

RBC – Rack Bonding Conductor: A bonding conductor used to connect an equipment rack directly to the TMGB, or TGB.

RGB/RBB – Rack Grounding Busbar/Rack Bonding Busbar: A busbar vertically mounted on an equipment rack. RBB is associated with low voltage work.

RCDD – Registered Communications Distribution Designer

RMC – Rigid Metal Conduit

RNC – Rigid Nonmetallic Conduit

RU – Rack Unit

SBB – Secondary Bonding Busbar: There is typically one (1) SBB per Telecommunications Room. The SBB is connected both to the PBB and to the building structural steel or other permanent metallic systems.

SCS - Structured Cable Systems

SMR – Surface Metal Raceway

TBB – Telecommunications Bonding Backbone: A conductor that interconnects the telecommunications main grounding-Primary bonding busbar (TMGB/PBB) to the telecommunications grounding-bonding busbar. (Optional due to costs and impedance related issues.)

TE – Telecommunications Enclosure: ICT/telecommunications cabinet wall/floor application or other ICT-related subset.

TEBC – Telecommunication Equipment Bonding Conductor

TGB/SBB – Telecommunications Grounding-Secondary Bonding Busbar: A common point of connection for telecommunications system and equipment bonding to ground and located in the telecommunications room or equipment room.

TIA – Telecommunications Industry Association

TMGB/PBB – Telecommunications Main Grounding-Primary Bonding Busbar: A busbar placed in a convenient and accessible location and bonded by means of the bonding conductor for telecommunications, to the building service equipment (power) ground.

TO – Telecommunication Outlet

TR – Telecommunications Room. TRs can provide wide range of ICT functions, including Horizontal Cross Connect (HC), Floor Distributor (FD), Building Distributor (BD), Campus Distributor (CD), Intermediate Cross Connection (IC).

TR-HC-FD – Telecommunications Room-Horizontal Cross Connect-Floor Distributor (IDF).

UBC – Unit Bonding Conductor: Interconnects the Rack Bonding Busbar to the telecommunications equipment.

UCC – Unified Communication and Collaboration

UPS – Uninterrupted Power Source

UTP – Unshielded Twisted Pair

Unconditioned – Spaces without heating or cooling including ceiling plenums.