



Regional Transportation District at Denver (RTD)

RTD IT CONSTRUCTION STANDARDS

Division 27 specifications (VER. 02.12.31)

The Regional Transportation District at Denver (RTD) Division 27 specifications are to be used for all RTD projects that involve the Office of the Regional Transportation District Information Technology (RTD IT) or working within the existence of RTD IT cabling and infrastructure.



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FORWARD

PROCESS TO ACCESS RTD INFORMATION TECHNOLOGY SYSTEMS (ITS) FACILITIES TO MAKE CHANGES

Purpose & Need

This process is documented to ensure work proposed to change ITS Systems follows a sequence of steps, and meets RTD's previous commitments, standards and needs.

Functional and Access Control of ITS Facilities

The responsibility of looking after RTD's Communications Infrastructure resides with the Communications Infrastructure Management Group (CIMG).

Technical Standards Related to Work

<https://www.rtd-denver.com/sites/default/files/files/2019-09/RTD-IT-STstandards-Division-27.pdf>

Responsibility for Technical Review of Work Proposed

Communications Infrastructure Group

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stsgroup@rtd-denver.com

RESPONSIBILITY FOR COMPLYING WITH PREVIOUS COMMITMENTS.

The CIMG will ensure that:

State professional licensure requirements are met.

Work is done by qualified professionals and contractors.

Work complies with applicable codes, regulations, and conditions of previous agreements with other entities.

INSURANCE COVERAGES REQUIRED FOR CONTRACTORS WORKING ON RTD FACILITIES

THESE WILL BE SPECIFIED BY RTD'S SENIOR MANAGER OF RISK MANAGEMENT BASED ON THE NATURE OF WORK PROPOSED.

ACCESS TO THE RTD RAIL CORRIDORS:

[HTTP://RTD-DENVER.COM/SITES/DEFAULT/FILES/FILES/2020-03/RAIL%20ACCESS%20PERMIT%20AND%20INSTRUCTIONS%2003-18-20.PDF](http://RTD-DENVER.COM/SITES/DEFAULT/FILES/FILES/2020-03/RAIL%20ACCESS%20PERMIT%20AND%20INSTRUCTIONS%2003-18-20.PDF)

BUILDING GROUNDS AND ACCESS PERMITS FOR OTHER RTD FACILITIES:

[HTTP://WWW.RTD-DENVER.COM/SITES/DEFAULT/FILES/FILES/2019-09/BGAP-FORM-AND-REQUESTER-INSTRUCTIONS%20-%202018.PDF](http://WWW.RTD-DENVER.COM/SITES/DEFAULT/FILES/FILES/2019-09/BGAP-FORM-AND-REQUESTER-INSTRUCTIONS%20-%202018.PDF)

RTD OFFICE USE ONLY

Project Name and Location:

Access to RTD’s ITS Facilities will only be allowed after the following factors have been evaluated, and requirements have been met.

Stage	By	Date
Design Plans reviewed by Communications Infrastructure Group and accepted		
Construction safety plans reviewed and accepted		
Third party coordination has occurred (CDOT, Local Jurisdiction, etc.)		
Bus bridge arranged for, if needed for Rail disruptions (very difficult to enable)		
Executed License Agreement and/or Executed Right-of-Entry		
Certificates of Insurance Received Railroad Protective Liability Insurance and RTD as additional insured, if applicable		
Traffic Control Plans accepted (Vehicles & Pedestrians)		
Detailed work plan reviewed and accepted by safety/operations/engineering and track protection measures (track out of service, flaggers, Lookout, engineering etc.) have been identified and scheduled.		
On-Track Safety Training, if applicable.		

Related Website

Please see <https://www.rtd-denver.com/business-center/construction-engineering>

Procedure History

REV	DATE	Change Originator	Signature	Chair CIMG	Description Change	Of
A	2020-XX-XX					

RTD IT CONSTRUCTION STANDARDS

Division 27 specifications (VER. 02.12.31)

SECTION 27 00 00

COMMUNICATIONS

PART 1 – GENERAL

1.01 SUMMARYS

A. The Regional Transportation District at Denver (RTD) Division 27 specifications are to be used for all RTD projects that involve the Office of the Regional Transportation District Information Technology (RTD IT) or working within the existence of RTD IT cabling and infrastructure.

B. “In-House” projects have the telecommunications low-voltage cabling and related infrastructure designed internally by the RTD IT Infrastructure Engineering Department and/or the RTD IT. The RTD IT department provides all related drawings and the Statement of Work referencing these Division 27 specifications. The telecommunications cabling and related infrastructure work for In-House projects are contracted directly by RTD IT with standing order contractors.

C. “Consultant Designed” projects have the telecommunications low-voltage cabling and related infrastructure designed by an outside Telecommunications / Low-Voltage Consultant, who provides all related drawings and specifications, based on these Division 27 specifications. The Telecommunications / Low-Voltage Consultant performing the design work shall follow specifications and standards created and maintained by the Institute of Electrical and Electronics Engineers (IEEE) The telecommunications low-voltage cabling work and related infrastructure work for Consultant Designed projects are contracted through the General Contractor.

D. The Telecommunications / Low-Voltage Consultant shall support and assist in the coordination of all RTD IT design requirements specified herein.

E. RTD IT has the right to change and update these Division 27 specifications at any time without notice. Contractors and Consultants shall work with the latest addenda to these specifications.

F. These specifications are posted on the RTD IT website on an annual basis. However, document form and addenda files are only supplied from RTD IT.

G. The cabling specified and shown on the drawings is for complete, performance based, workable systems. Deviations from the cabling shown due to a Manufacturer’s requirements shall be made only with the written approval of the Architect and the Owner (RTD), and at no additional cost to the Owner.

H. Related moves, additions and changes for services on the existing telecommunications station cabling are handled by RTD IT internally and are not covered by these specifications.

1.02 RELATED DOCUMENTS

A. The products and execution from these standards are the accepted practices from the RTD IT department and any products or execution outside these specifications will require written approval from RTD IT.

B. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to the telecommunications low-voltage work specified in Division 27.

C. Comply with the referenced codes and standards and with the Contract Documents.

Where conflicts occur, the more stringent shall apply.

The following codes, associations, acts and agencies, as required by law:

1. Americans with Disabilities Act (ADA)
2. Federal Communications Commission (FCC)
3. National Electric Code (NEC)
4. National Electrical Safety Code (NESC)

5. National Fire Protection Association (NFPA)
6. Occupational Safety and Health Administration (OSHA)
7. Federal Railroad Administration (FRA)
8. American Railway Engineering and maintenance-of-Way Association (AREMA)

The following standards:

1. American National Standards Institute (ANSI)
2. American Society of Testing Material (ASTM)
3. National Electrical Manufacturers Association (NEMA)
4. Telecommunications Industries Association (TIA)
5. Electronic Industries Association (EIA)
6. Institute of Electrical and Electronics Engineers (IEEE)
7. Underwriters Laboratories (UL)
8. American Standards Association (ASA)
9. RTD Safety Standards

D. In the event of a conflict or discrepancy between these specifications and other project documents, such as, but not limited to, drawing files, the Contractor shall submit proper paperwork to resolve the issue. Neither the specifications nor the drawing files (or other documents) prevail unless written clarification is provided from RTD IT.

E. The Contractor shall review related project documents and report any and all concerns prior to installation.

1.03 COMMUNICATIONS SYSTEMS

A. The communications design shall include the following systems as required for the specific project:

1. Communications Cabling and Hardware: T-Series
 - a. Cover with Legends.
 - b. Site Plan with Outside Plant.
 - c. Riser Diagrams with Conduit, Grounding, Voice, Utility, CenturyLink, in house phone, Multi-mode Fiber, Single-mode Fiber, Access Control, and CCTV.
 - d. Floor Maps with all Outlet locations.
 - e. Main Distribution Frame (MDF) Details with Footprint, Relay Rack Layout and Wall Design.
 - f. All additional Telecom Room (TR) Details with Footprint, Relay Rack Layout and Wall Design.
 - g. Remote Building Floor Maps related to the project.
 - h. Remote Building MDF/ER/TR Details related to the project.
 - i. Details sheet with Faceplates, Wireless Access Point (AP) Enclosures / Brackets, Camera Box, Floor Box, Stiff Leg Racks, Box Assembly, etc.
 - j. Maintenance hole butterfly details with site location, Hand hole butterfly details with site location, etc.
 - k. Outside Plant Prints.
2. Communications Demolition: TD-Series
3. Audiovisual: T-Series or dedicated AV-Series
4. Electrical Infrastructure: E-Series or EI-Series
 - a. Floorplans with infrastructure for telecommunications cabling distribution (conduit, cable trays, pull-boxes, j-hooks, etc.)

1.04 RTD WIRELESS DESIGN GUIDELINES CONSULTANT DESIGNED PROJECTS FOR NEW BUILDING CONSTRUCTION AND EXISTING BUILDING RENOVATIONS

A. The Regional Transportation District at Denver (RTD) new construction buildings and large renovation projects will include Project funds to engage an 802.11 wireless designer to perform 802.11 RSSI 3-D modeling to determine wireless Access Point (AP) placement and radio frequency propagation based on the modeling software and proposed building design drawings.

B. The RTD Construction Project Manager for Consultant Designed projects is directed to have the telecommunications low-voltage Consultant engage the services of a qualified 802.11 wireless designer. The services of the wireless designer can be contracted by issuing a PO billed back to the project.

C. The wireless designer shall be proficient in the use of ARUBA Wi-Fi Networks

D. The wireless designer will provide a report that will include all heat maps, material lists and executive summary detailing the parameters used for the modeling setup. The report will be submitted with a minimum two hard copies and one electronic copy.

E. RTD IT Operations will review the finished report before Architect/ Contractor engages the telecommunications low-voltage Consultant to accommodate AP placement in the T-series drawings. For questions related to this document please call (303) 299-6134, or Ext 6134 using an RTD based telephone.

F. Warranty Requirements

1. Project Warranty

a. **Equipment and materials required for installation under these specifications shall be the current model and new (less than one [1] year from date of manufacture), unused and without blemish or defect, and are to be guaranteed to be free from defect for a minimum of one year from date of project's substantial completion.**

b. When a defect or problem is observed within the first year after substantial completion, the Owner will notify the governing subcontractor through the proper channels. The appropriate Subcontractor then has 48 hours to fix the defect or furnish and install a replacement part/system, all at no cost to the project or Owner.

2. Advanced System Warranty for Telecommunications (Copper and Fiber Systems)

a. Beyond the initial one-year project warranty, the Copper and Fiber Telecommunications Systems shall be warrantied for a minimum of 15 years by a national and reputable connectivity or cabling manufacturer.

i. This warranty shall cover any material defect, as well as the performance of the cabling system. (Example: A Category 5e cabling system is to deliver 1000BASE-T speed, or 1 "Gig" performance for the entire length of the warranty period.)

ii. This warranty shall cover both material and labor for the full length of the warranty period.

1.05 RTD WIRELESS DESIGN GUIDELINES / IN-HOUSE PROJECTS

A. The Regional Transportation District at Denver (RTD) In-House project will have the 802.11 wireless design performed by RTD IT Operations staff to determine wireless Access Point (AP) placement and radio frequency propagation based on the modeling software and proposed building design drawings.

B. RTD IT Operations staff will provide the AP placement information to the RTD IT Infrastructure Engineering department to be shown on the T-series drawings. For questions related to the 802.11 wireless design for in-house projects, please call (303) 299-6134, or Ext 6134 using an RTD based telephone.

C. The Contractor shall submit for review and Approval, in accordance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, locations and mounting of all AP's.

1. AP locations can be moved prior to installation as per RTD IT instruction within 10 feet of original location with no extra cost to RTD
2. AP Locations in RTD buildings and office areas are limited to Breakrooms and Conference areas as per RTD Wi-Fi limitations and will require written approval for locations other than stated.

1.06 DESIGN DOCUMENTATION - GUIDELINES FOR TELECOMMUNICATIONS LOW-VOLTAGE CONSULTANTS

In reference to telecommunications low-voltage design work for Consultant Designed projects, RTD requires the telecommunications design effort be substantially complete and included in the publication of the initial design documentation set. The design elements expected in each phase, as a minimum, are listed below. The Consultant shall make it very clear what is new construction, and what is not, in renovation designs for existing buildings. All CAD drawings for telecommunications low-voltage infrastructure shall comply with the RTD IT Telecom CAD Standards

A. Schematic Design (SD) Phase documents shall be provided for review and comment by RTD IT.

1. Legend and Symbol Schedule shall be complete.

2. Site Plan shall be complete with all existing and new conduits, tunnels, handholes, maintenance holes, coaxial, and fiber optic cabling.
3. The RTD IT Division 27 Specifications shall be used for all project designs. Any items in these specifications that do not apply to the specific project shall be deleted with a strikethrough. Any additions to the specification for the specific project shall be highlighted with **RED** text. All changes to the specifications are subject to review and acceptance by RTD IT.
4. The locations for all TRs, ERs, and Comm Huts/Cases shall be designed to be within a 150' radius of all areas to be served with the understanding to maintain ANSI/TIA distance standards for telecommunications cabling.
5. The Telecommunications Rooms (TRs), Communication Huts (Comm Hut), Communication Cases (Comm Cases), and Equipment Rooms (ERs) and all support equipment should be located above the highest expected floodwater levels. No critical electronic, mechanical or electrical equipment should be located in basement levels.
6. New Telecommunications Rooms (TRs), Communication Huts (Comm Hut), Communication Cases (Comm Cases), and Equipment Rooms (ERs) shall be designed in compliance with the space, electrical, and environmental requirements of ANSI/TIA-569-D – Commercial Building Standard for Telecommunications Pathways and Spaces. Smaller spaces or enclosures shall not be acceptable without prior written approval from RTD IT.
 - a. Doors shall be a minimum of 1 m (3 ft) wide and 2.13 m (7 ft) high, without doorsills, hinged to open outward, slide side-to-side, or be removable. Doors shall be fitted with locks and have either no center posts or removable center posts to facilitate access for large equipment.
7. Environmental control HVAC systems shall be included in the designs for the TRs, ERs, and Comm Huts/Cases so that the temperature in these rooms will meet the requirements for ASHRAE Class B. The HVAC systems shall be designed to maintain a continuous operational range of 41°F to 80°F, with the maximum design load provided by the low-voltage consultant and approved by RTD IT. A positive pressure differential with respect to surrounding areas shall be provided. If a standby power source is available in the building, the HVAC system serving the TRs, ERs, and Comm Huts/Cases should be connected to the standby power. The ER/MDF rooms will have fan coil units placed outside the rooms, and the TR/IDF rooms will have VAV boxes that can be placed within the rooms, unless a different design is necessitated by the heat loads. RTD IT approval is required for alternate HVAC designs.
9. The maximum HVAC loads (BTU/Hr) and power consumption (Watts) for the TRs, ERs and Comm Huts shall be determined by the telecommunications low-voltage consultant based on the projected equipment growth for each room.
 - a. Bonding and Grounding (Earthing) systems for Telecommunications shall be designed and installed in compliance with ANSI/TIA-607-B.
10. Copper riser drawings shall be provided to document the project requirements for: RTD IT copper cable with protection; CenturyLink copper cable with protection; and backbone RTD IT copper cable and CenturyLink copper cable from the Main Distribution Frame (MDF) to each Telecom Room (TR) / Intermediate Distribution Frame (IDF) location.
11. Fiber riser drawings shall be provided to document the project requirements for: RTD IT Multimode (62.5/125), Multimode (50/125 – OM3) and Singlemode fiber cables; and RTD IT backbone Multimode (50/125 – OM3) and Singlemode fiber from the MDF to each IDF location.

B. Design Development (DD) Phase documents shall be provided for review and comment to RTD IT.

1. Environmental control system designs for the TRs, ERs, and Comm Huts/Cases shall be updated as necessary to meet ASHRAE Class B requirements with the updated heat loads from the low-voltage consultant.
2. The outlets shall be numbered on the floorplans, if not complete on SD phase. This includes outlets for wireless APs in the locations identified in the design from the 802.11 wireless designer.
3. Division 27 specifications shall be updated as required to reflect specific project requirements. All deletions shall be made with a strikethrough to the original text, and all additions shall be made with **RED** colored text, so that deviations from the original Division 27 specifications are clearly identified.

C. Construction Document (CD) Phase

1. This phase shall be used for final design updates to the T, TD, AV and EI drawings and Division 27 specifications for the project.
2. Environmental control system designs for the TRs, ERs and Comm Huts shall be updated as necessary to meet ASHRAE Class B requirements with the updated heat loads from the low-voltage consultant.
3. The 95% CD documents shall be submitted to RTD IT with 10 business days allotted for review and comment by RTD IT.
4. Final revisions shall be made to the CD documents to incorporate all RTD IT comments, and the 100% CD documents shall be submitted to RTD IT for final approval prior to construction.
5. When complete, all 100% CD drawing files shall be provided to the RTD IT Infrastructure in CAD format and PDF format.

D. Construction Phase

1. Design changes during construction shall be documented with updated T, TD, AV and EI drawings submitted to RTD IT as ASI (Architect's Supplemental Information), COB (Change Order Bulletin) and/or RFI (Request for Information) documents, as appropriate.
2. All ASI, COB, and RFI documents shall be submitted to RTD IT with 10 business days allotted for review and comment by RTD IT.
3. Final revisions shall be made to ASI, COB, and RFI documents to incorporate all RTD IT comments, and the final version of these documents shall be submitted to RTD IT for final approval prior to construction changes.

E. Submittal Review

1. The Consultant shall review and provide summary comments on product submittals to RTD IT.
2. The Consultant is NOT authorized to approve product submittals. Final approval of submittals will be provided by RTD IT when they are complete and correct.

F. As-Built Documents

1. After construction is complete, final as-built T, TD, AV and EI drawings for all communications infrastructure and cabling shall be provided to RTD IT Infrastructure Engineering Department in CAD format for final acceptance and work closeout.
2. Communication as-built files shall be a part of the final punch list and will not be considered complete until RTD IT receives the final as-built CAD files. Final payment shall be withheld until the as-built CAD files are received and approved by RTD IT.

1.07 CONSTRUCTION DRAWINGS AS-BUILT REQUIREMENTS

Memorandum of understanding between The Regional Transportation District at Denver (RTD), and Contractors to RTD IT for construction drawings issued for projects.

- A.** RTD IT will issue a PDF set of drawings to the Contractor for "In-House" IT projects. For Consultant Designed Facilities projects, drawings will be issued by the Architect/Consultant.
- B.** Contractor must have one full sized set of drawings on the job site for the purpose of marking as-built variations, and another set in their office. Drawings override any verbal statements made prior to or during project walk-through, or during construction. All changes must be written on the drawing with an RTD IT signature next to the change.
- C.** Any changes (i.e. redlines) made to the drawings shall require a RTD IT signature next to red lines allowing the change to be made. The Contractor may be requested to field verify existing layout. Redlines on the drawings based on field verification, shall not require a RTD IT signature next to the red lines, indicate "field verified" next to the red lines.
- D.** All outside plant copper/fiber and conduit jobs shall have cable and conduit distances noted on the "Cable/Conduit Footage and Count Information" sheet. Footages from end-to-end, between splices, and from splice to building fiber termination point in building (relay rack or fiber can) are required. The "SYM" column on the form corresponds to the fiber and copper designation bubbles on the topo drawings. Conduit type and length shall be noted on the topo drawings.
- E.** RTD IT will conduct an as-built walk-through with the Contractor prior to project completion. During this walk-through a punch list will be developed, and the accuracy of the red line changes will be determined.
- F.** As-built drawings for Consultant Designed Facilities projects shall be returned to the Architect/Consultant (or General Contractor depending on the project). Copies of the floor plans (i.e. jack maps) and jack position sheets shall be given to RTD IT prior to returning as-built drawings to the Architect/Consultant per this division standard.
- G.** All drawings issued by RTD IT for In-House projects shall be returned to RTD IT, whether or not as-built modifications (red lines) were made to the drawings. All red lines from the field set of drawings shall made to the original PDF set of drawings using PDF editor, and returned to RTD IT. The contractor must turn in the field copy with the red lines and an updated PDF set as their As-builds.
- I.** RTD IT maintains the right to return drawings to the Contractor for correction if information is incorrect or missing.
- J.** Architects/Consultants shall provide RTD IT an electronic Arch D size set of As-builds for their projects.
 1. The Contractor shall schedule, prepare and submit a complete shop drawing assembly in accordance with a time-table that will allow his suppliers and manufacturers sufficient time to fabricate, manufacture, inspect test and deliver their respective products to the project site in a timely manner so as to not delay the complete performance of the work.
- K.** The statement "Completed Per Print" is not acceptable.

1.08 COMPLETION OF FIBER CABELING AND ASSOCIATED COPPER AND WIRLESS SYSTEMS

The Contractor shall complete all work and turn over a completed and standards compliant optical fiber horizontal cabling system to meet the requirements of the RTD IT network system installation and activation. The scheduled date for completion of optical fiber cabling and associated copper and wireless systems shall incorporate the activation dates for services need to provide all services including voice, data, special systems needed for a Certificate of Occupancy, the testing and operation of Building Monitoring Systems, and Electronic Safety and Security Systems.

SECTION 27 01 00

OPERATION AND MAINTENANCE OF COMMUNICATIONS SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, Construction Manager/General Contractor (CM/GC) Agreement, Exhibits and other Division 1 Specifications, apply to this section.

1.02 CONTRACT ADMINISTRATION

A. Carefully study and compare the Contract Documents and at once report to RTD IT and/or the Consultant any error, inconsistency or omission identified. If the Contractor performs any construction activity knowing it involves a recognized error, inconsistency or omission in the Contract Documents without such notice, the Contractor shall assume appropriate responsibility for such performance and shall bear an appropriate amount of the attributable cost for correction.

B. Advise RTD IT as early as possible of any product delays and minimum quantity requirements that may affect the project timeline.

C. Immediately notify RTD IT Construction Manager (CM) and the Consultant, should conflicts, discrepancies, deficiencies, or errors arise which require changes in the Contract Documents. Failure to do so shall be interpreted as the intention of the Contractor to supply all necessary labor and materials for the suitable completion of this work. The Contractor shall obtain written approval on necessary adjustments before the installation is started.

D. In the event that the Consultant is required to provide additional engineering services as a direct result of the Contractor's errors, omissions or failure to conform to the requirements of the Contract Documents, then the Consultant's expenses in connection with such additional services shall be paid by the Contractor and may be deducted from any monies owed the Contractor.

E. In the event that the Consultant is required to provide additional engineering services as a result of substitution of equivalent materials or equipment by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Consultant is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Consultant's expenses in connection with such additional services shall be paid by the Contractor and may be deducted from any monies owed the Contractor.

1.03 PROJECT MANAGEMENT AND QUALITY ASSURANCE

A. Designate and identify a Project Manager (PM) to oversee the project work specified in this Division and to attend all project meetings as a representative of the Contractor. The Contractor's PM shall have the authority to act for the Contractor, and all communications given to the Contractor's PM will be deemed to have been given to the Contractor.

B. The Contractor shall not begin construction on any project without written notice to proceed.

C. All additional costs must be approved in writing with a change order signed by the RTD IT CM or authorized RTD IT management.

D. The Contractor's PM shall perform project management and coordinate all phases of the project with RTD IT staff.

1. Attend weekly project management meetings on site or at the IT Offices in the OPS Center at District Shops.

2. Provide and maintain a complete project schedule and timeline for all project activities including installation, inspection and testing for each work activity in each building. The project schedule will be provided by the Contractor's PM at the first project meeting within one week of contract award. The project schedule and timeline shall be updated as appropriate and will be provided and reviewed at each weekly project meeting thereafter.

E. Provide on-site job supervision:

1. Designate and identify on-site job supervisor in advance.

2. Provide no more than one supervisor per job.

3. Provide one primary contact, one backup contact.

4. Inform RTD IT if contact is unavailable.

5. Remove employees with behavior unacceptable to RTD.

F. Maintain the following information readily available to be provided to RTD upon request:

1. RTD IT Standards specifications (Division 27) specific to the project.

2. Submittals.

3. All Change Orders.
 4. The Field Observation and inspection reports.
 5. Test results.
 6. Schedule and outage logs.
 7. As-built drawings set showing all changes.
- G.** Maintain the following information on the job site:
1. All project related drawings.
 2. All addenda to the drawings.
 3. Approved T-5 jack position sheet for all horizontal cabling.
- H.** Assist RTD in performing periodic inspections for evaluation and functional testing of communications subsystems or sections, as completed. The Contractor shall assist RTD in performing evaluation and functional testing of complete communications system(s).
- I.** Conduct an overall quality assurance program.
- J.** Apply and install materials, equipment, and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the specifications shall be referred in writing to RTD for resolution.
- K. All products, components, devices, equipment and materials shall be new and unused (within less than one year of manufacture date), clean, free from defects, and free from damage and corrosion.**
- L.** Installation and service shall be performed by manufacturer trained and authorized personnel.

1.04 SUBMITTALS

- A.** For Consultant Designed projects, the Contractor shall submit, for review and approval, a complete list of all materials, components, equipment, systems, and products proposed.
- B. Product Data**
1. Product submittals are not required for manufacturer's products listed as "approved" in this Division 27 specification, unless specifically required in individual sections of this Division. However, listed manufacturers products are held to all conditions of this specification. The Contractor may be required to provide submittals for clarification of a specific item of equivalency prior to installation.
 2. Product submittals shall be provided for all products not listed as "approved" in this Division 27 specification. The product submittals shall show, as a minimum, the following:
 - a. Manufacturer
 - b. Complete model and part number.
 - c. Physical characteristics such as dimensions and color.
 - d. Technical specifications and performance data.
 - e. Any other pertinent information necessary to determine adequacy for the intended application.
- C.** For In-House projects, the Contractor is only required to submit a list and product data for those products not listed as "approved" in this Division 27 specification.
- D. Substitutions**
1. Requests to substitute for specified items or previously approved materials or equipment shall be submitted by the Contractor to RTD and the Consultant for review. Substitution requests shall include all required product data and shall be complete with reasons for substitutions and savings which will accrue to RTD if substitutes are approved. Substitutes will be considered only if equal or superior to that specified.
 2. Approval of alternate or substitute equipment or material in no way voids the Contract Document requirements.
 3. Under no circumstances shall RTD be required to prove that an item proposed for substitution is not equal to the specified item. It shall be mandatory that the Contractor submit to RTD all evidence to support the contention that the item proposed for substitution is equal to the specified item. The RTD decision as to the equality of substitution shall be final and without further recourse.
 4. The Contractor shall be liable for Consultant's costs for review and for incorporation of accepted substitutions if the proposed substitutions require design modifications. The Consultant may bill the Contractor standard hourly rates for the time used to review substitutions and to incorporate proposed substitutions into design documents.
 5. It shall be the responsibility of the Contractor to assure that the substitute material and/or equipment fits into the space provided and the Contractor shall pay for all extra costs incurred by other trades for any, and all changes necessitated by these substitutions.
 6. All product substitution requests are to be reviewed and approved by the Owner (RTD IT Representative). Not all requests will be approved, and all decisions are final, without recourse.
- E. Statement of Warranty**

1. Provide statement(s) of warranty based on the vendors', manufacturers' and Contractor's warranties.

F. Schedule

1. For Consultant Designed projects, the schedule shall be coordinated through the General Contractor and provided to the RTD Project Manager and the RTD IT Construction Manager (CM). The schedule must be in MS Project format, or other RTD approved equivalent, and shall include all major milestones and critical dates for project completion, including, but not limited to:
 - a. Required service activation dates (wireless network jacks, data jacks for building control, data jacks for LENEL, data jacks for security cameras, telephone lines for elevators, fiber for fire alarm loops, voice and data for occupancy, etc.)
 - b. Infrastructure completion dates (Telecom rooms, cable pathways, backbone cabling, station cabling, etc.)
2. For In-House projects, the Contractor shall submit a working schedule to RTD IT in MS Project format, or other RTD IT approved equivalent, within five business days from receiving notice to proceed.
 - a. The Working schedule shall identify all major milestones and planned dates including, but not limited to: T-5 template provided, materials ordered/received, construction start, cable pathways complete, cable complete and ready for testing, as-built drawing submittal, test result submittal.
 - b. If the communications project work is related to a construction project, the Contractor shall coordinate directly with the General Contractor to determine the overall project schedule, and the working schedule should identify any dates that are contingent upon work to be done by other trades (e.g., conduit, drywall, painting, etc.).
 - c. If the schedule for the communications project changes, the Contractor shall update and re-submit the working schedule within two business days of the schedule change.

G. T-5 Jack Numbering Position Sheet

1. For Consultant Designed projects, the Consultant shall submit the proposed telecommunications outlet numbers, using the T-5 template provided by RTD IT, for review and approval, prior to construction.
 - a. The T-5 shall be submitted at CD level. The first "Draft" T-5 shall be submitted with the first CD package. RTD IT will review and return comments with any corrections to be made. The Consultant shall submit the updated T-5, with corrections, within five business days of receiving RTD IT comments. This process shall be repeated until all corrections have been made and the Final 100% CD version is approved by RTD IT.
 - b. The Final 100% CD version of the T-5 shall be provided to the Contractor in electronic format prior to construction. The Contractor shall maintain hardcopy of the T-5 on-site and shall label all terminations in accordance with the T5, during construction.
 - c. If the quantity/location of telecommunications outlets changes during the post-CD construction process, the Contractor shall update and submit the T-5 to the RTD IT CM and the Consultant, with all changes highlighted. All changes to the T-5 must have the approved signature of the RTD IT CM before installation.
 - d. Once an outlet number has been assigned on the drawings and T-5 sheet, it shall never change for any reason. Deletion of outlets will not change any of the other outlet numbers on the drawings or T-5 sheet.
 - e. At least one (1) week prior to occupancy, or as agreed upon per the project schedule with RTD IT the Contractor shall submit an updated electronic copy of the T-5 sheet, to the RTD IT CM and the Consultant. The installed work and outlet numbering shall be based on the actual device locations and updated T-5.
 - f. Within two (2) weeks of final testing, the Contractor shall submit the tested T-5 to the Consultant and the RTD IT CM, with all testing corrections. The tested T-5 shall be submitted in electronic format.
 - g. Within four (4) weeks of final testing, the Consultant shall submit the verified "As-Built" T5 to RTD IT Infrastructure Engineering Department.
2. For In-House projects, the Contractor shall submit the proposed outlet numbers, using the T-5 template provided by RTD IT, for review and approval, within 5 business days from receiving notice to proceed.
 - a. RTD IT will review and return comments with any corrections to be made. The Contractor shall submit the updated T-5, with corrections, within two business days of receiving RTD IT comments. This process shall be repeated until all corrections have been made and the "Final" version is approved by RTD IT.
 - b. The Contractor shall maintain hardcopy of the T-5 on-site, and shall label all terminations in accordance with the T5, during construction
 - c. If the quantity/location of telecommunications outlets changes during the construction process, the Contractor shall update and re-submit the T-5 to the RTD IT CM, with all changes highlighted. All changes to the T-5 must have the approved signature of the RTD IT CM before installation.
 - d. Once an outlet number has been assigned on the drawings and T-5 sheet, it shall never change for any reason. Deletion of outlets will not change any of the other outlet numbers on the drawings or T-5 sheet.

e. At least one (1) week prior to occupancy, or as agreed upon per the project schedule with RTD IT, the Contractor shall submit an updated electronic copy of the T-5 sheet to the RTD IT CM. The installed work and outlet numbering shall be based on the actual device locations and updated T-5.

f. Within two (2) weeks of final testing, the Contractor shall submit the "As-built" T-5 to the RTD IT CM.

H. As-Built Drawings

1. At the beginning of work, set aside one complete hardcopy set of the project drawings, which shall be maintained as a complete "as-built" set.

2. Record all changes and deviations on the as-built drawing set. Changes that must be noted on the as-built drawing set include, but are not limited to, changes to cabling, materials, cable routing, equipment placement, equipment numbering and labeling, etc. In addition, installed cable footages for all backbone cabling shall be recorded on the as-built drawings.

3. Any field changes shall be red-lined on the drawings and must have the approved signature of the RTD IT CM prior to installation. Notations and changes shall be made in a neat and legible manner by marking the original drawings with red pencil to indicate additions and green pencil to indicate deletions.

4. Field verify existing conditions and red-line any deviations on the project drawings. Red-lines based on field verification, do not require RTD IT signature, but should have "field verified" indicated next to the red-lines

5. The RTD IT CM will conduct an as-built walk-through with the Contractor prior to project completion. During this walk-through, a punch list will be developed, and the accuracy of the red line changes will be determined.

6. Comply with the attached document: CONSTRUCTION DRAWINGS AS-BUILT REQUIREMENTS.

7. All drawings issued are required to be returned to RTD IT, whether or not as-built modifications (redlines) are made to the drawings.

8. As-built document requirements apply to all projects, unless written approval is received from RTD IT. The as-built documents shall not be delayed for delivery to RTD IT for any reason.

9. For Consultant Designed projects, 100% CD documents shall be issued to the Contractor by the Architect / Consultant as specified in Section 27 00 00.

a. All design changes during construction shall be documented and communicated via ASI, COB, and/or RFI documents, as specified in Section 27 00 00.

b. All drawing changes during construction shall be submitted to the RTD IT CM and the Consultant in electronic format.

c. The Contractor shall submit hard copy and electronic copy of the final as-built drawings, including red-lined field changes, to the Consultant and to the RTD IT CM within two (2) weeks of completion of the project. This will be in addition to any submittals to the General Contractor and/or the Architect.

d. The Consultant has the final responsibility to provide as-built drawing files, in AutoCAD format, to the RTD IT Infrastructure Engineering Department for final acceptance and work close out.

i. RTD IT will return drawings to the Consultant for correction if information is incorrect or missing. Corrected resubmittals shall be provided to the RTD IT Infrastructure Engineering Department within two (2) weeks of comment.

j. For In-House projects, drawings will be issued to the Contractor in Adobe PDF format from the RTD IT Infrastructure Engineering Department

1. All drawing changes during construction shall be submitted to the RTD CM in electronic format.

2. The Contractor shall submit hard copy and electronic (PDF) copy of the final as-built drawings, including red-lined field changes, to the RTD IT CM within two (2) weeks of completion of the project.

3. All red line changes from the field set of drawings shall be made to the original PDF drawings using PDF editor.

4. RTD IT will return drawings to the Contractor for correction if information is incorrect or missing. Corrected resubmittals shall be provided to the RTD IT CM within one (1) week of comment.

K. Test Results and Configuration Information

1. Upon completion of the work the Contractor shall submit final test results and configuration information, as required by each of the individual Division 27 specification sections.

2. Standard test sheets will be used for fiber optic cabling.

3. Test sheets for communication jacks and copper backbone cabling will not be supplied to the Contractor by RTD IT.

4. As-built test results shall be submitted to RTD IT in PDF format using the test equipment's standard output report, including the auto summary page and individual test results for each communication jack.

5. Comply with the manufacturer's most current warranty procedure and documentation requirements. All testing documentation including, but not limited to the "Structured Cabling System Registration Request Form," "Horizontal Schematic," and "Backbone Schematic," shall be completed in full and shall include the installers full name, company name, telephone number, date completed, and RTD IT jack outlet with faceplate port numbers (e.g., 202-1D-1C5e-1D-3). All documentation shall be provided to both the manufacturer and RTD IT for warranty.

6. As-built test results for Consultant Designed projects shall be submitted to the RTD IT CM and the Consultant by the Contractor within two (2) weeks of project completion.
7. As-built test results for In-House projects shall be submitted to the RTD IT CM by the Contractor within one (1) week of project completion.
8. Pursuant to required warranty validation documentation and procedures for cabling to support specialized technology systems, the Contractor shall provide such documentation as required to the system manufacturer, with a copy to the RTD IT CM.

1.05 PERMITS, LICENSES, INSPECTIONS AND FEES

- A.** Obtain all required permits, licenses and inspections and shall pay all legal and proper fees and charges including taxes, royalties, and other related charges. No work shall be started before obtaining all necessary permits and paying all required fees.
- B.** Provide RTD with copies of all required building and trade permits, if said are required, at inception of work.
- C.** Furnish and file with the proper authorities all drawings required by them in connection with this work.
- D.** Arrange all inspections and secure all required signatures. Upon completion of the work, properly completed permits shall be returned to RTD, if any are required.

1.06 PERIODIC INSPECTIONS AND FIELD OBSERVATION REPORTS

- A.** RTD IT will conduct site visits for required inspections and to monitor the progress and quality of the work and the work environment, as well as the surrounding facility. Any item found by RTD IT to be deficient will be documented on an Inspection Form and/or a Field Observation Report.
- B.** Take appropriate action to immediately correct and rectify any items deemed unsatisfactory by RTD IT. The Contractor shall not wait for a hard copy of the Field Observation Report if the action required to rectify the situation is obvious and clear.

1.07 INSPECTIONS AND TESTS

- A.** Furnish promptly, without additional charge, all test equipment, instruments, facilities, labor, and material needed to perform safe and convenient inspection and testing.
- B.** Prior to beginning work, submit to RTD a complete project schedule and timeline including installation, inspection, and testing for each project area so that interim inspections can be conducted as work progresses. RTD shall not be obligated to inform the Contractor of its intent to inspect job sites while work is in progress.
- C.** Perform pre-testing of the installed telecommunications systems to determine compliance and the RTD IT CM when the system is ready for final inspection and testing. The RTD IT CM, or designated representative, will be present for final inspection and testing within five business days of such notification by the Contractor.
- D.** At such time as the RTD IT CM directs, and in the presence of the RTD IT CM or designated representative, conduct final inspection and testing of all telecommunications systems, both new and existing where modified.
- E.** Except as otherwise provided in the specifications, inspection and testing of materials and work performance shall be made at reasonable times and at the site of the work.
- F.** RTD IT may determine that inspection or testing of materials, such as fiber optic cabling, shall be made offsite, at the place of production, manufacture, or shipment of the material. Such off-site inspection or testing shall not relieve the Contractor of responsibility for damage to, or loss of, the material prior to acceptance, nor in any way affect the continuing rights of RTD after acceptance of the completed work.
- G.** Work shall not be covered up or enclosed until inspected by RTD IT personnel or other proper authorities. Should any work be covered up or enclosed before such inspection, it shall be uncovered, inspected, and after approval, restored by the Contractor to finished condition at no additional cost to RTD.
- H.** All work that is determined to be unsatisfactory shall be corrected immediately. The Contractor shall, without charge, replace any material or correct any work quality found by RTD not to conform to the specifications, unless RTD consents to accept such material or work quality with appropriate adjustment in price. The Contractor shall promptly segregate and remove rejected material from the premises. The Contractor shall pay the additional cost of any test or inspection of the replaced material or corrected work quality.
- I.** The Contractor shall prepare reports of final test results, together with RTD IT standard test sheets and all additional pertinent information and submit these in electronic PDF format the RTD IT CM and the Consultant for acceptance.
- J.** The telecommunications rooms, and other rooms containing communications technology systems identified as part of the work scope for the project, shall be labeled and laid out well in advance of testing. This includes the outlet numbers on the patch panels (as soon as the racks are mounted), to allow pre-inspections, prior to testing for large projects.

1.08 CONTINUITY OF SERVICES AND SCHEDULING

- A.** The buildings and or facilities may be in use during construction operations. Insofar as possible, the Contractor shall employ such methods or means as will not cause interruption of, or interference with, the owner's scheduled use of the building and will maintain existing systems in operation within all rooms and areas of the building or facility at all times.
- B.** For areas under renovation, coordinate all installation activities with RTD and other trades for renovations of architectural, mechanical, and/or electrical facilities. Insofar as possible, the Contractor shall employ such methods or means as will not cause interruption of, or interference with, the work of any other contractor.
- C.** Moving or removing any facility must be done so as not to cause interruption of the project work or of RTD operation.
- D.** Disruption of critical services will require after hour or weekend working constraints.
- E.** Existing communication services shall be interrupted only with consent from RTD. An advance warning time of a minimum of seven working days shall be given. Such interruptions shall be preceded by all possible preparations which will minimize down time to expedite that particular phase of the work pursuant to good work performance. This shall be done at regular and premium time as approved by RTD without additional expense to RTD.
- F.** Adjust work schedule within reason (weekly), as per direction of RTD, and coordinate with work or other trades in order to make portions of project available to RTD as soon as possible.
- G.** All expenses due to untimely or improperly coordinated work shall be the responsibility of the Contractor.

1.09 USE OF CABLE PRIOR TO ACCEPTANCE

- A.** The Contractor shall permit the placement and installation by RTD of cross-connects, patch cords, and/or equipment onto cable and terminations installed under this contract, prior to substantial completion of the contract as necessary. Such placement or installation shall not evidence completion of the work or portion thereof, nor signify RTD acceptance of the work or portion thereof.
- B.** Cabling and equipment provided under this contract, whether the work of the Contractor is partially or fully completed or not, shall be the property of RTD. RTD shall have certain rights and privileges in connection with use of same.

1.10 FINAL ACCEPTANCE AND WORK CLOSEOUT

- A.** The contractor shall correct all punch list items and fully inspect and test the entire telecommunications system installation, to assure all work is completed and all systems are completely operational, before calling for final inspection, testing and acceptance of work by RTD IT.
- B.** After the successful installation inspections and functional testing by RTD IT and the Contractor, RTD IT will determine if there are any open issues or discrepancies and notify the Contractor. Upon completion or determined failure, RTD IT will issue written notification to the Contractor as to the status of the installation acceptance.
- C.** Contractor close-out prior to invoicing:
 1. Notify RTD IT when telecommunications work is ready for final inspection, testing, and punch list preparation.
 2. Complete all testing with RTD IT CM, or designated representative.
 3. Correct all punch list items and notify RTD IT when ready for final punch list close-out.
 4. Submit as-built T-5 documents, drawings, and test results to RTD IT and the Consultant / Architect. Keep copies for Contractor file.
 5. Final payment will not be authorized until all punch list items have been resolved and completed to the satisfaction of RTD IT, with as-built files turned in and approved by RTD IT, and warranty statements received.
- D.** Project closeout will be approved by RTD IT after:
 1. All punch list items have been completed, inspected and accepted by RTD IT.
 2. Final as-built T-5 documents have been received and accepted by RTD IT.
 3. Final as-built drawings have been received and accepted by RTD IT.
 4. Manufacturer's warranty statements have been received by RTD IT.

SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, Construction Manager/General Contractor (CM/GC) Agreement, Exhibits and other Division 1 Specifications, apply to this section

1.02 SCOPE OF WORK

A. Work includes, but is not limited to, the following:

1. Placement of, and additions to, Telecommunications Rooms (TRs), Communication Huts (Comm Hut) and Equipment Rooms (ERs) hardware, including equipment racks, cable routing hardware, copper, fiber, and coaxial cable termination equipment, patch cords, and grounding and bonding.
2. Placement of, and additions to, hardware for Technology systems for Offices, break rooms, conference rooms, and Platforms including technology cabinets, equipment racks, cable routing hardware, copper, fiber, and coaxial cable termination equipment, patch cords, and grounding and bonding.
3. Placement of, and additions to, interior telecommunications pathways including conduit, cable tray, pull-boxes, metallic surface-mount raceway systems, and j-hooks, as approved by RTD IT on a case-by-case basis.
4. Placement of, and additions to, exterior telecommunications pathways including trenching/backfill, conduit system, pull-boxes, handholes, maintenance holes and cable routing hardware.
5. Installation and termination of backbone cabling, including copper cabling, coaxial cabling, and singlemode and multimode fiber optic cabling.
6. Installation and termination of horizontal cabling, including copper cabling, coaxial cabling, and single/multimode fiber optic cabling.
7. Testing, identification, and administration for the above telecommunications systems.
8. Removal of existing horizontal cabling, terminations, and outlets in coordination with electrical contractor for removal of associated cable pathways.

B. All work shall be conducted in coordination with RTD IT and other building trades.

C. The work covered by this Division consists of furnishing all materials, accessories, connectors, supports, electrical protection, equipment, tools, setup, preparation, labor, supervision, incidentals, transportation, storage, and related items and accessories, and performing all operations necessary to complete the telecommunications work as indicated in the project drawings and specified herein. It is the intent and purpose of this specification to have, upon completion of the project, a “turn-key” telecommunications system designed, built, coordinated and integrated with the existing telecommunications system and complete and operable in all respects. Completely install, connect, and test all systems, equipment, devices, etc., shown or noted or required to final connections and leave ready for satisfactory operation. Provide any minor items omitted from the design, but obviously necessary to accomplish the above intent.

D. All telecommunications design for RTD buildings and platforms must be approved by the RTD IT department for standards and design structure. Any design outside of these RTD IT standards must be approved and include a written agreement for the design from the RTD IT Department.

E. Minimum composition requirements and/or installation methods for the following materials and work are included in this section:

1. Cables
2. Factory Assembled Products
3. Compatibility of Related Equipment
4. Special Tools and Kits
5. Firestops and Penetration Seals
6. Anchoring and Supports
7. Grounding and Bonding
8. Cutting and Patching
9. Concealment
10. Equipment Modification

1.03 GLOSSARY

- A. ANSI American National Standards Institute
- B. ASHRAE American Society of Heating and Air-Conditioning Engineers
- C. ASTM American Society for Testing and Materials
- D. BICSI Building Industry Consulting Services International
- E. FCC Federal Communications Commission
- F. IEEE Institute of Electrical and Electronics Engineers
- G. ISO International Organization for Standardization
- H. NEC National Electrical Code
- I. NEMA National Electrical Manufacturers Association
- J. NESC National Electrical Safety Code
- K. NFPA National Fire Protection Association
- L. OSHA Occupational Safety and Health Administration
- M. RTD Regional Transportation District at Denver
- N. RTD IT Office of Information Technology
- O. TIA Telecommunications Industry Association
- P. UFBC Uniform Fire Prevention and Building Code
- Q. UL Underwriter's Laboratories, Inc.

1.04 CONFORMANCE

- A. References to regulations, codes, and standards mean the latest edition, amendment and revisions to the regulations, codes and standards in effect on the date of the Contract Documents.
- B. All work and materials shall conform to and be installed, inspected, and tested in accordance with the governing rules and regulations of federal, state, and local government agencies.
- C. Installations, materials, equipment and work quality shall conform to the specifications and drawings and all applicable provisions of the most recent versions of the following regulations, codes, and standards including all applicable addenda:
 1. NFPA 70 / NEC
 2. NESC (IEEE)
 3. NFPA 101 Life Safety Code
 4. ASTM Standards
 5. IEEE Standards
 6. NEMA Standards
 7. ANSI/TIA – Telecommunications Cabling Standards including, but not limited to, 568-C.0, 568-C.1, 568-C.2, 568-C.3, 568-C.4, 569-D, 598-D, 455 Series, 472 Series, 492 Series, 526 Series, 604 Series, 606-B, 607-B, 758-B, 942-A.
 8. ICEA-S-83-596
 9. FCC Code of Federal Regulations (CFR)
 10. Applicable State of Colorado codes including UFBC and Department of Labor Rules and Regulations
 11. Applicable Municipal codes
 12. Applicable codes and regulations of other authorities having lawful jurisdiction pertaining to the work required
 13. Americans with Disabilities Act (ADA)
 14. RTD Standards
 15. BICSI Telecommunications Distribution Methods Manual, Telecommunications Cabling Installation Manual, Customer-Owned Outside Plant Manual, LAN and Internetworking Design Manual, AV Design Reference Manual.
 16. American Railway Engineering and maintenance-of-Way Association (AREMA)
 17. Federal Railroad Administration (FRA)
- D. All modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to RTD.
- E. Report immediately to RTD IT personnel and/or the Consultant, in writing, any part of the telecommunication system design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- F. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the telecommunications design. Drawings and specifications take precedence where this design is more stringent than codes and ordinances.

G. All materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.05 EMERGENCY FACILITIES

A. Maintain at all times free access to fire lanes and emergency and utility control facilities such as fire hydrants, fire alarm boxes, utility vaults, maintenance holes, pull-boxes, etc.

B. Work shall not interfere with legal fire exits. Corridors, areas of egress, fire protection standpipes, hydrants, and exit stairs shall be maintained at all times.

1.06 SAFETY AND HEALTH REQUIREMENT

A. These construction documents and all phases of construction completed are to be governed by applicable provisions of the “Williams-Steiger Occupational Safety and Health Act of 1970, Public Law 91-596” and the latest amendments including, but not limited to:

1. Reporting/Investigating Accidents
2. Enforcement of Program
3. Telecommunications 1910.268
4. Hazard Communication 1910.1200
5. Confined Space 1910.146
6. Lockout/Tagout 1910.147
7. Asbestos 1910.1001
8. Assured Grounding 1926.404
9. Portable Wood Ladders 1910.25
10. Portable Metal Ladders 1910.26
11. Electrical Protection 1910.268
12. Exposure and Medical Records 1910.20
13. Emergency Evacuation 1910.38
14. Hantavirus/General Duty Clause/CDC Guidelines

B. Comply with RTD regulations and safety requirements, including, but not limited to, Rail Safety, work in confined spaces, and mitigation of asbestos, and other hazardous materials.

C. All applicable state, federal and local safety regulations shall be adhered to and all operations shall be conducted in a safe manner.

D. Contractor personnel working in hazardous areas shall have current training and applicable certification.

E. Provide hazards training certificates for all personnel working in hazardous areas.

F. Inspect work sites for hazards regularly.

G. Provide safety program documents as required for each project.

H. Provide Rail Safety Training as required for each project on or near the Rails (On Track Safety).

I. Comply with National Electrical Safety Code NESC

J. Take all reasonable precautions for safety of, and provide reasonable protection to prevent damage, injury, or loss to:

1. personnel conducting project work and other persons who may be affected thereby
2. existing facilities, whether or not such facility is to be removed or relocated
3. project work and all materials and equipment to be incorporated therein, whether in storage or offsite, under care, custody or control of Contractor or any subcontractors
4. installed equipment and existing construction
5. other property at the site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, fences, roadways, structures and utilities not designed for removal, relocation or replacement in the course of construction.

K. Assume responsibility for construction safety at all times and provide, as part of contract, all trench or building shoring, scaffolding, shielding, dust/fume protection, mechanical/electrical protection, special grounding, safety railings, barriers, and other safety features required to provide safe conditions for all workers and site visitors.

L. Moderate public pedestrian traffic should be expected around all work locations. Ladders, scaffold, installation materials, and all other hazardous conditions must be fully protected at all times. Warning cones, barricades, warning tapes, etc. shall be used to warn and protect persons and property at all times in public areas.

M. Comply with any and all code related and RTD specific safety requirements for work to be performed in confined spaces or on the Rail system. This shall be provided to Contractor employees at the expense of the Contractor and at no cost to RTD

N. Comply fully with National Electrical Safety Code NESC and RTD specific safety requirements for work in electrical high voltage power maintenance holes. Only licensed electricians may perform work in electrical high voltage power maintenance holes. In addition, an RTD high voltage electrician escort is required to be on site throughout the time work is being conducted by contractors (including standing order electricians) in any high voltage power maintenance holes or vaults.

1.07 LOCATION AND PROTECTION OF UTILITIES

A. Notwithstanding any other provisions of the contract, Contractor shall be solely responsible for location and protection of any and all public lines and utility customer service lines in the work area.

1.08 DEFINITIONS

A. Every effort has been made to use industry standard terminology throughout this specification, but industry standard terminology is not used by all manufacturers and, in many cases, industry standard terminology does not exist. Contractor shall notify the RTD IT Manager and/or the Consultant to define terminology used in specifications if they believe any questions could arise.

B. Approved/Approval Written permission to use a material or system

C. Consultant Telecommunications Low-Voltage Consultant / Designer for Division 27 work for "Consultant Designed" projects, as defined in Section 27 00 00

D. Contractor Telecommunications Contractor performing work under Division 27

E. Equal/Equivalent Equally acceptable as determined by RTD IT

F. Final Acceptance RTD acceptance of the project from Contractor

G. Furnish Supply and deliver to installation location

H. Inspection Visual observation at job site by RTD representative

I. Install Mount and connect equipment and associated materials ready for use

J. Jack Modular connector for station cabling medium (UTP copper, fiber, coax) at work area outlet.

K. Outlet Box and faceplate to accommodate up to six (6) modular jacks at the work-area.

L. Pull-Box Box to be used for pull-through of cabling in a conduit run. Not to be used as a junction box.

M. Provide Furnish and install complete with all details and ready for use

N. Relocate Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use

O. Replace Remove and provide new item

P. Telecommunications All work specified in Division 27

Q. Where this Division 27 indicates work to be performed by the words "shall" or "secure" or other performance functions, it shall be assumed that such work shall be performed by the telecommunications Contractor performing work under Division 27.

1.09 DRAWINGS AND SPECIFICATIONS

A. It is the intention of these specifications and related project drawings to call for finished work, tested and ready for operation in complete accordance with all applicable codes, regulations, standards, and ordinances.

B. These specifications and the project drawings are complimentary, and what is called for in either of these shall be binding as though called for by both. Should any conflict arise between the drawings and specifications, such conflict shall be brought to the attention of the Consultant and the RTD IT Manager for resolution. If the Contractor fails to contact the Consultant and RTD IT Manager in writing of any conflict between the specifications and the project drawings, the Contractor shall be subject to re-work the area of conflict at the Contractor's cost.

C. Omissions from the specifications and/or project drawings or the incorrect description of details of work which are evidently necessary to carry out the intent of the specifications and project drawings, or which are customarily performed, shall not relieve the Contractor from performing such omitted or incorrectly described detail of the work. All work shall be performed as verified in field measurements, field construction criteria, material catalog numbers and similar data checked and coordinated with each shop drawing by the Contractor.

D. The telecommunications and technology project drawings are diagrammatic and indicate general design, layout, and arrangement of equipment and various systems. Being diagrammatic, the drawings may not necessarily show all details such as pull-boxes, conduit runs or sizes, etc., necessary for a complete and operable system. Unless detailed dimensioned drawings are included, exact locations are subject to approval of RTD

E. Do not scale project drawings for dimensions. Take all dimensions and measurements from the site and actual equipment to be furnished. All dimensions, measurements, and the location and existence of underground equipment must be verified in the field since actual locations, distance, and elevations will be governed by actual field conditions. Contractor shall be responsible for all measurements taken from the field.

1.10 EXAMINATION OF PROJECT SITE

A. Prior to any project work, the Contractor shall examine the project site carefully, including all project drawings showing existing systems and equipment. The Contractor shall be fully informed of and shall identify all utility, state, and local requirements that will affect the telecommunications work at the project site.

B. It shall be the Contractor's responsibility to determine if the installation of the proposed systems will affect the operation or code compliance of existing systems. With RTD approval, relocate, modify, or otherwise revise existing telecommunications systems as required to maintain operational integrity and code compliance.

C. The Contractor shall become familiar with the local conditions under which the work is to be performed and correlate the on-site observations with the requirements of the specifications and project drawings. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.

D. Before ordering any materials or doing any project work, verify all measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the project drawings. Any discrepancies found shall be submitted in writing to the Consultant and the RTD IT Manager for consideration before proceeding with the project work.

1.11 WORK QUALITY, WARRANTY, AND SUPPORT

A. Materials and work quality shall meet or exceed industry standards and be fully guaranteed for one full year from final acceptance for each project. Cable integrity and associated terminations shall be thoroughly inspected, fully tested and guaranteed as free from defects, transpositions, opens/shorts, tight kinks, damaged jacket insulation, etc.

B. Furnish a written warranty to RTD for a minimum of:

1. One-year materials warranty on parts and labor to repair/replace defective telecommunications materials specified herein. This warranty only applies to materials provided by Contractor and does not apply to materials provided by RTD.
2. Twenty-five-year manufacturers' materials warranty on parts and labor to repair/replace defective telecommunications station cabling materials. The Installer/contractor shall be certified by the manufacturer to provide the materials warranty.
3. One-year installation work quality warranty on parts and labor to resolve problems related to telecommunications system installation work performance or quality.

C. The Contractor shall be responsible for, and make good, without expense to RTD, any and all defects arising during this warranty period that are due to imperfect materials, appliances, improper installation, or poor work performance or quality.

1. During the warranty period, provide all labor required to repair or replace defects in the telecommunications system, at no cost to RTD.
2. During the warranty period, provide new materials to repair or replace defects in the telecommunications system, at no cost to RTD.
3. If the Contractor or his approved subcontractor does not resolve such stated areas of dissatisfaction within thirty (30) days, the Owner may appoint any alternative service agency or person to fulfill the terms of the Warranty; the cost of which shall be borne by the contractor. This action may be taken repeatedly until the Owner is satisfied that Warranty service performance is satisfactory. Satisfactory resolution of a malfunction shall be considered adequate when the device, equipment, system or component which is chronically malfunctioning is brought into compliance with the standards of performance as contained herein and published by the manufacturers of the equipment installed.

PART 2 – MATERIALS

2.01 EQUIPMENT AND MATERIALS MINIMUM REQUIREMENTS

A. All materials and equipment provided by the Contractor shall be new (within less than one year of manufacture date), free from defects, installed in accordance with manufacturer's current published recommendations in a neat manner and in accordance with standard practices of the industry.

B. Where no specific material, apparatus, or appliance is mentioned, any standard, first-class product made by reputable manufacturer regularly engaged in the production of such material may be used providing it conforms to the contract requirements and meets the approval of RTD IT and the Consultant.

C. Rated materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, in accordance with NFPA 255.

D. Materials shall meet or exceed the following minimum requirements:

1. Where applicable, all materials and equipment shall bear the label and listing of UL. Application and installation of all listed equipment and materials shall be in accordance with such labeling and listing.

2. Equipment shall meet all applicable FCC regulations.
3. Electrical equipment and systems shall meet UL standards and requirements of the NEC. This listing requirement applies to the entire assembly. Any modifications to equipment to suit the intent of the specifications shall be performed in accordance with these requirements.
4. The listing of a manufacturer as “acceptable” does not include acceptance of a standard or catalogued item of equipment. All equipment and systems must conform to the specifications and meet the quality of the specified item.
5. Materials and equipment shall bear the manufacturer’s name or trademark and model/serial number permanently marked.
6. Materials and equipment must be documented and listed in a document with manufacture name, model, serial number and any other identifying marks or numbers with unit pricing for asset management and turned over to RTD IT.
7. The Owner reserves the right to use equipment, material and services provided as part of this work prior to Acceptance of the Work, without incurring additional charges and without commencement of the Warranty period.

2.02 CABLES

- A. All telecommunications cabling inside the building shall be UL listed and marked type CM, CMR, CMP, CCTV, CATV, CATVR or CATVP and shall be installed in accordance with NEC articles 300, 800 and 820.
- B. All fiber optic cable inside the building shall be UL listed and marked type OFN, OFNR, or OFNP and shall be installed in accordance with NEC articles 300 and 770.

2.03 FACTORY ASSEMBLED PRODUCTS

- A. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for the final assembled unit.
 1. All components of an assembled unit need not be products of the same manufacturer.
 2. Constituent parts, which are alike, shall be the product of a single manufacturer.
 3. Components shall be compatible with each other and with the total assembly for intended service.
 4. Contractor shall guarantee performance of assemblies of components and shall repair or replace elements of the assemblies as required to deliver the specified performance of the complete assembly.

2.04 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that a complete and fully operational system will result.

2.05 SPECIAL TOOLS AND KITS

- A. Furnish any special installation equipment, tools, or kits necessary to properly complete the telecommunications system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly and adjustment devices, etc.
- B. RTD IT Standing Order contractors shall provide a complete list of all tools and kits annually, at the beginning of each contract year.

2.06 FIRESTOPS AND PENETRATION SEAL MATERIALS

- A. Use qualified systems to firestop through penetrations in all fire-rated walls, floors, and assemblies for pipes, cables, conduits, ducts, inner-ducts, and cable trays.
- B. Firestopping for openings through fire-rated walls, floors, and assemblies shall comply with all requirements of RTD Standards.
- C. Cabling for telecommunication applications shall be sealed with re-enterable firestopping products.
- D. Firestopping devices shall be pre-manufactured modular devices, containing built-in self-sealing intumescent inserts. Firestopping devices shall allow for cable moves, additions or changes without the need to remove or replace any firestop materials. Devices must be capable of maintaining the fire resistance rating of the penetrated membrane at 0% to 100% visual fill of penetrants: while maintaining “L” rating of <5 cfm/sf at 0% to 100% visual fill. Each device must be capable of retrofit applications and be available in square and round configurations, with single, double, triple and six-plex bracket systems provided. Firestop devices must also allow for plastic pipe, metallic pipe, and mixed multiple penetrations (plastic, metallic, insulated metallic, and cable) through a single device.
- E. Inside all conduits, the firestop system shall consist of a dielectric, water-resistant, non-hardening, permanently pliable/re-enterable putty along with appropriate damming or backer materials (where required). The sealant must be capable of being removed and reinstalled and must adhere to all penetrants and common construction materials and shall be capable of allowing normal cable movement without being displaced.

F. Approved Firestop Manufacturers:

1. 3M Fire Protection
2. Specified Technologies, Inc. (STI)
3. HILTI

G. The firestop system shall be submitted to RTD IT with a list or map of each location and system number used for the project. The submittal shall include a penetration schedule that shows typical penetrations of each penetrating material's type and the proposed firestop system.

H. Submit detailed drawings including manufacturer's descriptive data, typical details conforming to UL Fire Resistance or other details certified by another approved nationally recognized testing laboratory, installation instructions or UL listing details for a firestopping assembly in lieu of fire-test data or report. Submittal shall indicate the firestopping material to be provided for each type of application. When more than a total of 5 penetrations and/or construction joints are to receive firestopping, provide drawings that indicate location, "F", "T" and "L" ratings and type of application.

2.07 ANCHORING MATERIALS AND SUPPORTS

A. Metal bars, plates, channel, tubing, etc. shall conform to ASTM Standards:

1. Steel plates, shapes, bars, and grating – ASTM A36
2. Cold-formed steel tubing – ASTM A500
3. Hot-rolled steel tubing – ASTM A501
4. Steel pipe – ASTM A53, Schedule 40, welded

B. Metal fasteners shall be zinc-coated.

C. Anchoring Materials:

1. Structural Steel
2. Steel Channel: Galvanized or painted
3. Uni-Strut

2.08 GROUNDING AND BONDING MATERIALS

A. Mechanical Connectors: Bronze.

B. Bonding Conductor: 6 AWG minimum copper

C. All grounding equipment shall be UL listed for that purpose.

PART 3 - EXECUTION

3.01 EXAMINATION OF PROJECT SITE

A. Prior to any project work, examine the project site carefully, including all project drawings showing existing systems and equipment. The Contractor shall be fully informed of, and shall identify, all utility, state, and local requirements that will affect the telecommunications work at the project site.

B. Examine areas and conditions under which the specified work is to be done. Provide written notification to the RTD IT Manager of conditions detrimental to proper completion of the work.

C. Verify field measurements and conditions are as shown on project drawings. Provide written notification to the RTD IT Manager of conditions deviating from drawings.

D. Beginning of telecommunications work indicates Contractor acceptance of existing conditions.

E. Determine if the installation of the proposed systems will affect the operation or code compliance of existing systems. With RTD approval, relocate, modify, or otherwise revise existing telecommunications systems as required to maintain operational integrity and code compliance.

F. Become familiar with the local conditions under which the work is to be performed and correlate the onsite observations with the requirements of the specifications and project drawings. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.

G. Before ordering any materials or doing any project work, verify all measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the project drawings. Any discrepancies found shall be submitted in writing to the Consultant and the RTD IT Manager for consideration before proceeding with the project work

H. The approximate locations of existing and new telecommunications outlets, cabling and equipment will be indicated on the project drawings; however, the drawings are not intended to give complete and accurate information. Field verify existing outlets and cabling

prior to submitting a quote. Determine the exact locations after thoroughly examining the general building plans and by actual measurements before and during construction, subject to the approval of RTD IT and the Consultant.

I. Before construction work commences, visit the site and identify the exact routing for all cable pathways and equipment placement. Verify all dimensions, locating the work and its relation to existing work, all existing conditions and their relation to the work and all human made obstructions and conditions, etc. affecting the completion and proper execution of the work as indicated in the project drawings and specifications.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. All equipment locations shall be coordinated with RTD IT, other trades and existing conditions to eliminate interference with required clearances for equipment maintenance and inspections.

B. Coordinate work with RTD, other trades and existing conditions to determine exact routing of cable, cable tray, hangers, conduit, etc., before fabrication and installation.

C. If core drills are required, the exact core locations shall be identified and coordinated with RTD as necessary. X-rays may be required prior to core drilling in some surfaces. Identify and abide by all RTD core drilling requirements.

D. Install telecommunications cabling and equipment to facilitate maintenance and repair or replacement of equipment components. Provide easy, safe and code mandated clearances at equipment racks and enclosures, and other equipment requiring maintenance and operation. Coordinate with RTD exact location and mounting height of all equipment in finished areas, such as equipment racks, termination equipment, communication and electrical devices. As much as practical, connect equipment for ease of disconnecting, with a minimum of interference with other installations.

E. Coordinate ordering and installation of all materials and equipment with long lead times or having major impact on work by other trades so as not to delay the job or impact the schedule.

F. Set all equipment to accurate line and grade, level all equipment and align all equipment components. All work shall be installed level and plumb, parallel and perpendicular to other building systems and components.

G. Provide all scaffolding, rigging, hoisting, lifts, and services necessary for delivery, installation, and erection of materials, equipment, and apparatus furnished into the premises. These items shall be removed from premises when no longer required. Use of RTD owned supplies and equipment is prohibited.

3.03 WORK QUALITY AND PERFORMANCE

A. All labor shall be thoroughly competent and skilled, and all work shall be executed in strict accordance with the best practice of the trades.

B. Good work quality, performance and appearance shall be considered of equal importance with telecommunications operation. Lack of quality work and performance shall be considered sufficient reason for rejection of a system in part or in its entirety. Carefully lay out all work in advance and install in a neat and skillful manner in accordance with recognized good practices and standards. Provide workmen who are skilled in their craft and a competent Project Manager who will be on the job at all times.

3.04 CABLES

A. Backbone and horizontal station telecommunications cabling shall be placed in separate dedicated pathways. Cable trays shall be clearly divided between backbone and horizontal station cabling.

B. Telecommunications pathways shall be dedicated for use for RTD IT voice, data, CCTV, CATV, and AV cabling. Other services on RTD IT cables (intercom, audio, video, security, fire, BAS, DAS, etc.) may be placed in telecommunications pathways only with prior written approval from RTD IT.

C. Horizontal cabling for other services may be allowed within the RTD IT pathways per the following guidelines and acceptance of written approval from RTD IT. RTD IT must understand and accept the services to be used on the Horizontal cabling as to not create interference with other services within the pathways. RTD IT will be the sole owner of the horizontal cabling with jacks on both ends that will be installed and tested per this Division 27 standard. Other terminations and systems can be reviewed by RTD IT but all Horizontal cabling for other services must be approved in writing from RTD IT.

D. All horizontal cabling terminating within a single faceplate must be routed to and terminated in the same ER, TR or Comm Hut.

E. Consolidation points and multi-user telecommunications outlet assembly (MUTOA) configurations for horizontal cabling are not currently supported by RTD IT and will not be permitted.

3.05 CUTTING AND PATCHING

- A. Provide all cutting, patching and core drilling, etc., as necessary for telecommunications work in accordance with RTD Standards. Locate holes and outlets to be drilled, coordinate with work of other trades, and obtain approval of RTD prior to cutting or core drilling holes greater than ¾" in structural members.
- B. Cut and drill from both sides of walls and/or floors to eliminate splaying.
- C. Patch adjacent existing work disturbed by installation of new work, including insulation, walls and wall covering, ceiling and floor covering and other finished surfaces. Patch openings and damaged areas equal to existing surface finish.
- D. Cut openings in prefabricated construction units in accordance with manufacturer's instructions.
- E. Openings for electrical work shall be carefully caulked or grouted as required. Spare conduits shall be tightly capped.
- F. All cutting in the building construction made necessary to admit work, repair defective materials, defective work quality, or by neglect of the Contractor to properly anticipate his requirements, shall be done in accordance with these specifications with no additional cost to RTD. Patching shall be complete in every detail. Actual work involved in these repairs shall be done by skilled craftsmen in the trades involved.
- G. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
- H. Clean up and vacuum all spaces after cutting and patching to remove all debris from the work.

3.06 CONCEALMENT

- A. Use existing conduit and cable trays and conceal all project work above ceilings and in walls, below slabs, and elsewhere throughout building where possible and practicable. If concealment is impossible or impracticable, notify the RTD IT Manager and the Consultant before starting that part of the work, and install only after approval is given by RTD IT.

3.07 EQUIPMENT MODIFICATION

- A. Where existing equipment is to be modified, furnish materials and labor as necessary to modify or add to the equipment. Modifications shall be done neatly with factory parts and assemblies approved for the application. Modification shall in no way jeopardize the compliance of existing equipment with any governing codes and regulations.

3.08 FIRESTOPS AND PENETRATION SEALS

- A. All new and existing penetrations through fire-rated walls, floors, ceilings, etc. shall be sealed to prevent the spread of smoke, fire, toxic gas, or water through the penetration either before, during, or after a fire. The fire rating of penetration seal shall be at least that of the wall, floor, or ceiling into which it is installed, so the original fire rating is maintained. The installation shall provide an air and watertight seal. This includes all existing telecommunications cables and pathways to remain within the project area.
- B. All new and existing conduit and sleeve openings used for the project shall be waterproofed or fireproofed upon cable placement through such passageways in compliance with Colorado Building and Fire Codes and RTD Standards
- C. Firestop systems shall be installed where required by building code and in accordance with the UL list and manufacturer's guidelines.
- D. Each installed firestop shall be labeled for identification in accordance with RTD Standards
- E. Patch all openings remaining around and inside all new and existing conduit sleeves and cable penetrations to maintain the integrity of any fire-rated wall, floor, ceiling, etc.
- F. Manufacturer's installation standards shall be closely followed (minimum depth of material, use of ceramic fiber, procedures, etc.).
- G. Cable Trays: All new cable tray pathways shall not penetrate fire-rated walls. Cable tray shall stop within 6 inches of the wall and a fire-rated assembly shall be used for the wall penetration, such as EZ path product or equivalent approved by RTD IT.
- H. Seal all foundation penetrating conduits and all service entrance conduits and sleeves to eliminate the intrusion of moisture and gases into the building. This requirement also includes spare conduits.
- I. Spare conduits shall be plugged with expandable plugs.
- J. All service entrance conduits through the building shall be sealed or resealed upon cable placement.
- K. Entrance conduits with cables in them shall be permanently sealed by firmly packing the void around the cable with oakum and capping with a hydraulic cement or waterproof duct seal.

3.09 ANCHORING METHODS

- A. Anchor and brace all cabling, material, and equipment installed under this Division as required by all codes, regulations, and standards. Provide required supports, beams, angles, hangers, rods, bases, braces, straps, struts, and other items to properly support project work. Supports shall meet the approval of RTD.
- B. Supports shall be fabricated from structural steel, steel channel, or uni-strut, rigidly bolted or welded to present a neat appearance.

- C. Fastenings and supports shall be adequate to support loads with ample safety factors.
- D. Fasten hanger rods, conduit clamps, outlet boxes, and pull-boxes to building structure.
- E. Use toggle bolts, spider type expansion anchors, or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls.
- F. Use lead expansion shields or expansion anchors or preset inserts in solid masonry walls.
- G. Use self-drilling anchors or lead expansion anchor on concrete surfaces.
- H. Use sheet metal screws in sheet metal studs.
- I. Use wood screws in wood construction.
- J. In pre-cast structures, use cast-in inserts wherever possible. Expansion anchors can be used with caution, but only with prior approval from RTD.
- K. In cast-in-place concrete, use expansion anchors, preset inserts, or self-drilling masonry anchors.
- L. Use lead expansion anchors, or preset inserts on metal surfaces.
- M. Do not fasten supports to piping, ceiling support wires, ductwork, mechanical equipment, or conduit.
- N. Power-actuated anchors, plastic or fiber expansion anchors, and drive pin anchors are prohibited.
- O. Do not drill structural steel members.
- P. Any anchoring must be able to be unsecured and removed should relocation be required. The old Hilti HIT-pin is not acceptable.
- Q. Where necessary and with approval from RTD, modify studs, add studs, add framing, or otherwise reinforce studs in metal stud walls and partitions as required to suit project work. If necessary, in stud walls provide special supports from floor to structure above.
- R. For precast panels/planks and metal decks, support communication work as determined by manufacturer and RTD.
- S. Provide heavy gauge steel mounting plates for mounting project work. Mounting plates shall span two or more studs. Size, gauge, and strength of mounting plates shall be sufficient for equipment size, weight, and desired rigidity.
- T. Install freestanding telecommunications equipment on concrete pads.
- U. Support surface mounted cabinets, enclosures, and panelboards with a minimum of four anchors.
- V. On exterior concrete walls below grade, provide 1" steel channel stand-offs for cabinets and raceways.
- W. Use stud bridges at top and bottom of cabinets and enclosures that are flush mounted on hollow drywall walls.
- X. Use suitable vibration isolation pads for vibrating equipment.

3.10 GROUNDING AND BONDING

- A. Bond all new metallic cable shields and metallic supporting structures, in all equipment rooms and service entrances, including racks, frames, protectors, and cabinets to the existing telecommunications grounding busbar (TGB), according to the manufacturer's specifications.
- B. Do not make connections between the telecommunications busbar system and building electrical grounds, or other types of connections, without RTD approval.
- C. Bond metallic surfaces of telecommunications hardware with #6 AWG grounding wire as straight as possible to the ground source.
- D. Ensure that the grounding system is physically secured.
- E. All grounding conductors leaving the ER, TRs and Com Huts shall be in a separate conduit from all communication cabling.
- F. All grounding items shall be installed in complete compliance with NEC.

SECTION 27 05 28

PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD IT Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section.

1.02 SCOPE OF WORK

A. Provide all services labor, materials, tools, and equipment required for the complete and proper installation of interior and exterior telecommunications pathways as called for in these specifications and related drawings.

B. This section includes minimum requirements and installation methods for the following:

1. EMT Conduit Systems
2. Cable Tray Systems
3. Surface Metal Raceway Systems
4. Wireless Access Point (AP) Boxes

1.03 QUALITY ASSURANCE

A. All installation work for the new interior telecommunications pathways shall be performed in a neat and skillful manner. All methods of construction that are not specifically described or indicated shall be subject to the control of RTD.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval of RTD based on submittals provided.

C. Installations, materials, equipment and work quality shall conform to the specifications and drawings and all applicable provisions of the most recent versions of the following regulations, codes, and standards including all applicable addenda:

1. ANSI/NFPA 70 – National Electrical Code including, but not limited to, the following articles:
 - a. 250 – Grounding and Bonding
 - b. 300 – General Requirements for Wiring Methods and Materials
 - c. 314 – Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Hand hole Enclosures
 - d. 358 – Electrical Metallic Tubing: Type EMT
 - e. 386 – Surface Metal Raceways
 - f. 392 – Cable Trays
 - g. 770 – Optical Fiber Cables and Raceways
2. ANSI/TIA-568-C.0 – Generic Telecommunications Cabling for Customer Premises
3. ANSI/TIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA-569-D – Commercial Building Standard for Telecommunications Pathways and Spaces
5. ANSI/TIA-606-B – Administration Standard for Commercial Telecommunications Infrastructure
6. ANSI/TIA-607-B – Generic Telecommunications Bonding and Grounding for Customer Premises
7. ANSI/TIA-942-A – Telecommunications Infrastructure Standard for Data Centers
8. BICSI Telecommunications Distribution Methods Manual

1.04 SUBMITTALS

A. As-built drawings showing pathways (conduit, pull-boxes, cable tray, J-hooks, etc.) for all projects

B. Electrical as-built drawings showing pathways for Consultant Designed projects.

PART 2 – MATERIALS

2.01 EMT CONDUIT SYSTEMS

A. Electrical Metallic Tubing (EMT): Electro-galvanized steel tubing 3/4” and larger diameter per project requirements:

1. Conduit joint couplings and connectors: steel double set screw indenter fittings
2. Metal bushing for each connector for all sizes of conduit
3. Metal bushings with grounding lugs as required
4. Conduit sweeps: minimum 10 times the conduit inside diameter
5. Include required conduit straps, and hangers, heavy-duty malleable iron or steel
6. LB fittings and plastic fittings are not permitted
7. Nipple runs from one outlet box to another outlet box are not permitted
8. Install a pull wire in each and every conduit.

B. Outlet boxes: Galvanized steel sheet metal 4 – 11/16” x 4 – 11/16” x 2-1/8” deep minimum with single gang mud ring.

C. Pull-boxes: Minimum 14-gauge galvanized steel with screw fastened cover and trim for flush or surface mounting as required for project. Dimensions as required for project.

1. Box extensions are prohibited for new construction however they are permitted on remodel work to extend existing installations.

D. Metal Flex Conduit (3/4”) and deep Cut-In Boxes for outlets in existing walls for remodel projects only.

E. Location, Wet. Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, unprotected locations exposed to weather.

1. The inside of a raceway is a wet location and a raceway installed underground are considered wet locations. Therefore, any conductors contained therein would be required to be suitable for wet locations.

F. Mule-tape: polyester or aramid line with a minimum pull tensile strength of 200 pounds for backbone conduit.

G. Poly line: poly pull line with a minimum pull tensile strength of 200 pounds for station conduit.

2.02 CABLE TRAY AND SUPPORT SYSTEMS

A. Cable Trays in Ceiling Areas:

1. Welded wire mesh cable system sized per drawings.
2. Include components, and compatible fittings designed and manufactured by the cable tray manufacturer as required for a fully installed electrically continuous system.
3. Include support kits, brackets, threaded rod hangers, lateral threaded rod braces, and other anchors and supports as required and specified.

B. Cable Support in Ceiling Areas:

1. J-hooks specifically designed for low-voltage cable support sized per drawings.
2. Perforated pipe strap, bridle rings, or wire hangers are not permitted.
3. Plastic cable ties are not permitted to support station cabling in any location.

2.03 SURFACE METAL RACEWAY SYSTEMS

A. Surface Metal Raceway Systems (SMRS):

1. Surface Raceway: Steel Raceway with Ivory color finish
2. Surface Raceway Parts and Fittings (SRPF):
3. Surface Single gang box to mount faceplate with modular furniture (existing modular raceways shall be used only for pathway).
4. Surface Single gang extension box to mount on surface raceways (the surface raceways shall be used only for pathway). For all fiber jacks these extension boxes MUST be used for all Faceplates mounted over electrical boxes with a single-gang mud rings or cut-in single-gang boxes.
5. Extra deep Surface Single gang extension box for all faceplates on flat surfaces.
6. Include all parts and components: base and cover, compatible fittings, metal bushings, and supports designed and manufactured by the raceway manufacturer as required for a complete installation.

2.04 INNERDUCT SYSTEMS

A. In new construction and new conduit, fiber optic backbone cables shall always be installed in fiber optic innerduct. Normally, three to four innerduct can be placed in a four (4)-inch conduit. Where fiber optic cable is installed into existing conduits, the use of fiber optic innerduct is preferred if space is available. Innerduct is used to separate and segregate cables, and to prevent the tangling of cables in a conduit.

B. All integral innerducts shall have a continuous non-spliced, unknotted detectable 1250 pound test 22AWG detectable mule tape installed.

C. All newly installed fiber optic cable shall be placed inside fiber optic innerduct, preferably orange in color. Innerduct shall be used to segregate and identify fiber optic cables in all telecommunications maintenance holes and at all locations where fiber optic cable is exposed.

D. Where drawings or requirements call out for innerduct, the contractor shall furnish and install 1 ¼ - inch corrugated innerduct within the conduit system as well extending out of conduits or sleeves to termination points.

- E.** Plenum-rated innerduct shall meet UL 910 and UL 2024 requirements.
1. Shall be constructed of a PVC Riser rated or plenum rated plastic as required.
 2. Shall be 1" or 1 ¼ "in diameter as called for on the drawings.
 3. Shall be orange in color.
 4. Shall be UL listed to 2024 standard.
- F.** The contractor shall furnish and install innerduct (minimum three quarter inch (¾ ")) for any location where cabling extends out from floor cores and into furniture system splines, or to bridge a gap between a cabling pathway to an architectural element. In such cases, the innerduct shall be black in color and consist of any of the following:
1. Corrugated tubing
 2. Split harness tubing
- G.** All fiber shall be installed in 1 ¼ " minimum corrugated, non-metallic plenum rated innerduct when not installed in conduit or in utility tunnel tray.
1. Innerduct shall be UL Listed with Flame Propagation compliant with UL 2024.
 2. Innerduct shall be riser or plenum rated, as required for the environment in which it is placed.
 3. Innerduct shall be flexible, corrugated, and non-metallic.
 4. Innerduct shall NOT be required where optical fiber cabling construction is specified with a jacketed interlocking armor.
- H.** Orange innerduct shall be required with all optical fiber cabling; indoor and outdoor. All conduit designated to contain interbuilding and outside plant (OSP) optical fiber shall also be filled with spare innerducts comprising the full capacity of that conduit. For example, a 4" OSP conduit shall contain a minimum of (3) 1" innerducts in all cases the cabling installation requires use of the conduit. Un-used conduits shall be left vacant except for pull strings or mule tape.
- I. Products**
1. Orange, plenum rated, UL Listed, flexible optical fiber/communication raceway.
 2. Recognized per NEC Articles, 770 and 800 for plenum areas for optical fiber and telecommunications cables.
 3. Provide all fittings to form a complete integrated raceway system.
- J.** Where fiber optic cable is installed, the use of fiber optic innerduct is preferred. Innerduct is used to separate and segregate cables, and to prevent the tangling of cables.
1. Follow Innerduct Standards listed in TIA-758-B

PART 3 - EXECUTION

3.01 PATHWAY INSTALLATION

- A.** Place new pathways and support systems as shown on the project drawings.
- B.** Perform installation of pathways as specified
- C.** Conduit, cable tray, J-hook, and surface raceway systems shall be so installed, that no cable run will exceed 290' in length from the Telecommunications Room (TR), Equipment Room (ER) or Communication Huts/Cases to the farthest outlet. Where building conditions prohibit meeting this requirement, notify the RTD IT Manager and Consultant immediately for resolution. Additional TRs, ERs or Comm Huts/Cases may need to be provided.
- D.** Where any portion of a horizontal cable run will be routed outside, or under slab, 1" conduit shall be provided for the entire route from the outlet to the ER, TR or Comm Hut.
- E.** Ceiling tile shall be removed as necessary for the conduit, cable tray, J-hook, and support system installation, and shall be put back in place without damaging or dirtying any of the tiles or supporting framework. Ceiling tile shall be handled with clean hands so that no fingerprints or marks are left on the tiles. The Contractor is responsible for the cost of repair or replacement of any damaged or dirtied tiles or ceiling hardware.
- F.** When installing through tile ceiling grid, conduit or raceway shall be extended above top of ceiling grid to a pull box feeder system or within 6" of the cable tray. Ceiling tiles shall be notched to the size of conduit or raceway along the edge of the tile. Holes shall not be cut in the middle of ceiling tiles.
- G.** Coordinate pathway routes with other trades.
- H.** For J-hooks, cable tray, or non-metal pathways, maintain the following clearances from EMI sources:
1. Unshielded power lines or equipment less than 5 kVA: 12"

2. Unshielded power lines or equipment equal to or greater than 5 kVA: 24"
 3. Power lines enclosed in grounded metal conduit less than 5 kVA: 6"
 4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 12"
 5. Fluorescent fixtures: 12"
 6. Motors or transformers: 48"
- I. For grounded metal pathways (conduit), maintain the following clearances from EMI sources:
1. Unshielded power lines or equipment less than 5 kVA: 6"
 2. Unshielded power lines or equipment equal to or greater than 5 kVA: 12"
 3. Power lines enclosed in grounded metal conduit less than 5 kVA: 3"
 4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 6"
 5. Fluorescent fixtures: 6"
 6. Motors or transformers: 36"

3.02 CONDUIT, CABLE TRAY, AND SUPPORT SYSTEM INSTALLATION

- A.** No section of conduit shall be longer than 30 m (100 ft) between pull points (e.g., outlet boxes, telecommunications closets, or pull-boxes).
- B.** The inside radius of a bend in conduit shall be at least 10 times the conduit internal diameter. Bends in the conduit shall not contain any kinks or other discontinuities that may have a detrimental effect on the cable sheath during cable pulling operations. Where cabling requires larger bends, the conduit bends shall comply with the cable manufacturers' and TIA requirements.
- C.** No section of conduit shall contain more than two 90° bends, or equivalent bends exceeding 180° total, between pull points. If there is a reverse (u-shaped) bend in the section, a pull-box shall be installed. Of the 180° offsets, kicks shall not exceed 30 degrees.
- D.** 3-point saddles are not permitted in conduit runs.
- E.** A minimum of two (2) 4" conduits shall be installed through gypsum walls and ceilings greater than 3' wide in corridors, and around all corridor corners or intersections with gypsum ceilings.
- F.** Provide pull-boxes as required to accommodate cable pulling and code compliance due to field conditions for each project.
- G.** Install pull-boxes in readily accessible locations. Equipment, piping, ducts, and the like shall not block access to the boxes. The Contractor shall coordinate access doors as required to provide access to pull boxes in hard ceilings and similar inaccessible areas.
- H.** Conduits terminating into cable trays or J-hooks shall end no more than 6" away from the tray or J-hook.
- I.** Install dedicated 1" conduit for each telecommunications outlet to the nearest pull-box, cable tray, or J-hook support system.
- L.** Conduit for fiber optic fire alarm cable shall be separate, dedicated 3/4" conduit for the entire distance from the outlet to the MDF room.
- M.** Minimum conduit size for telecommunications station cabling shall be 1".
- N.** Stub out conduits through walls into the TRs, ERs and Comm Huts only enough to attach connector and bushings with grounding lugs.
- O.** Stub out conduits through floors into the TRs, ERs and Comm Huts to extend a minimum of 6 inches above the finished floor.
- P.** The ends of the metallic conduit shall be reamed and bushed using:
1. Metal bushings for each connector for all sizes of conduit
 2. Metal bushings with grounding lugs as required, including all conduit entering TRs, ERs and Comm Huts
- Q.** Cut ends of metallic conduit shall be filed to remove burs.
- R.** Bond all metallic pathways (conduit, cable tray, etc.) entering the TRs, ERs and Comm Huts to the TGB or TMGB in the same room with #6 AWG grounding wire as straight as possible.
- S.** Support conduits, cable tray, and J-hooks from building structure using suitable Unistrut, threaded rod, straps, racks, or hangers. Supporting conduits, cable trays, or J-hooks from ceiling suspension wires is not permitted.
- T.** Install conduit support within 18" of each termination, and a maximum of 7' between supports along the conduit route.

- U.** Spacing between J-hooks shall not exceed 4' along the entire route.
- V.** Support pull-boxes independently from building construction. Pull boxes shall not be supported from conduit.
- W.** Install conduit expansion fittings with external grounding straps at building expansion joints.
- X.** Install new Mule-tape in all new conduits prior to pulling backbone cable. The Mule-tape shall extend three feet from each end of the conduit and shall be knotted and secured to remain in place.
- Y.** Install new Poly line in all new conduits prior to pulling horizontal cable. The Poly line shall extend three feet from each end of the conduit and shall be knotted and secured to remain in place.
- Z.** Conduit, cable tray, and J-hooks shall not be installed adjacent to hot surfaces or in wet areas.
- AA.** Metal flex conduit and deep cut-in boxes shall be installed for outlets in existing walls for remodel projects only. The flex conduit shall be connected to a pull-box within 4' of entering ceiling space from wall space. Flex conduit and deep cut-in boxes are not allowed in new construction.
- BB.** Conduit, cable tray, and J-hook sizes and routes and pull-box sizes and locations shall be coordinated with the RTD IT Infrastructure Engineering Department for each project.
- CC.** Conduit, cable tray, J-hooks and support systems shall be installed with adequate clearance from fire sprinkler heads so that they do not block any part of the sprinkler's coverage pattern.
- DD.** If it is necessary to core drill surfaces or burn holes through webs of beams or girders, the receive written approval from RTD as to the location and size of the hole before proceeding with work. Abide with RTD Standards for all cutting and patching work. All holes shall be cut or burned no larger than absolutely necessary.
- EE.** Support cable tray with manufacturer's supports and/or using threaded, galvanized rod hangers with rods extended through support steel and double-nutted. Support members shall be sized within load rating of the member section and without visible deflection. Excess threaded rod ends shall be cut off flush with the bottom of the double nut.
- FF.** Install cable tray level and straight to the extent possible.
- GG.** Where cable trays abut walls, supports shall be provided to the walls.
- HH.** Install cable tray supports at a minimum of 8' on center and at all ends, intersections and angles.
- II.** A minimum of 12" headroom shall be provided above all cable trays, except where specifically allowed in writing by RTD IT.
- JJ.** A minimum of 8" horizontal clearance shall be provided on at least one side of all cable trays, except as specifically allowed in writing by RTD IT.
- KK.** A minimum 4" clearance shall be provided from the top of ceiling grid structure to the bottom of cable tray, J-hooks, and pull boxes.
- LL.** All cable tray shall be installed in compliance with clearances specified.
- MM.** Install the cable tray system so that the electrical continuity of the system is maintained.
- NN.** Install body expansion connectors for cable trays at building expansion joints.
- OO.** Install external grounding straps at expansion joints, sleeves, crossovers and other locations where cable tray continuity is interrupted.
- PP.** Support racks for telecommunications conduit and or cable tray must be dedicated for telecommunications pathways only. Multi-use suspension systems for plumbing and other piping along with electrical and telecommunications pathways are not permitted.
- QQ.** Label all conduit, pull-boxes, and cable tray with "Telecom" stickers at each end and every 75 feet.
- RR.** Separate dedicated pathways (conduit, cable tray, J-hooks, etc.) shall be provided for backbone and horizontal telecommunications cabling. Cable trays shall be clearly divided between backbone and horizontal cabling.
- SS.** Cable trays shall not pass through any firewall or fire-rated walls or surfaces. Cable tray shall end before the firewall and transition to the EZ Path per manufacturer's specifications. The cable through the EZ Path shall not exceed 60% fill, so that and 40% future fill shall remain.
- TT.** Firestop and seal all pathways and core drills through fire rated walls and floors as specified.

3.03 SURFACE METAL RACEWAY INSTALLATION

- A.** For outlets in surface raceway, a single-gang extension box shall be installed on the front of the raceway, so jacks do not protrude into pathway, as shown in the drawing attached at the end of this Section.

- B.** Perform installation of routing hardware as specified, including anchoring and supports, grounding and bonding, firestop, etc. Anchors shall be used for attachment to surface. Use of adhesives is prohibited.
- C.** Cut raceways square and ream ends to remove burs at raceway connections to outlets.
- D.** Raceways shall be installed parallel or perpendicular to building walls, floors and ceilings.

3.04 TELECOMMUNICATIONS OUTLETS AND WIRELESS ACCESS POINT (AP) ENCLOSURES

A. The locations of outlet boxes and wireless AP enclosures shown on project drawings are approximate. The exact location of outlet boxes and enclosures shall be governed by structural conditions, obstructions, or other equipment. The Contractor shall furnish any special installation equipment, tools, or kits necessary to properly complete the system installation.

1. Unless otherwise noted, outlet boxes shall be located as follows (dimensions are above finished floor to center line of boxes):
 - a. Standard telecommunications outlets: 1'6"
 - b. Wall-mount telephone outlets: 4'6"
 - c. ADA Wall mount telephone outlets: 4'0"
2. All ADA standards shall be met when applicable.
3. Adjust outlet box locations so that they will be symmetrically located and not interfere with other equipment.
4. Where outlets of other types are adjacent, heights shall be coordinated to be similar where possible.
5. Where outlets are located on masonry walls, box location shall be adjusted to set in the corner of the block or brick.
6. Back to back outlet boxes are not permitted. Boxes shall be separated a minimum of 6" in standard walls and a minimum of 2' in acoustical walls.
7. Protecting publicly visible / accessible endpoints (ex. jacks or ports in stations) from tampering, destruction, misuse, or accidental disconnection by covering, shielding, or boxing them off physically.
 - a. Use port locks/RJ45 jack Security covers to seal off jacks in public areas and all tools or keys associated with the covers to be given to RTD IT.
 - b. Preferred Port locks/RJ45 jack Security covers
 - i. Black Box #PL-AB-BK
 - ii. Panduit #PAN-PSL-DCJB
8. Where conflicts are noted for outlet box locations, coordinate with RTD IT and Facilities Management.
9. Outlet box locations may be adjusted by RTD up to six (6) feet from the location shown on drawing with no additional cost to RTD.

B. Support outlet boxes independently from building construction. Boxes shall not be supported from conduit or raceways.

C. For wall mounted wireless APs, install a Wireless Right-Angle Wall Bracket.

1. For new walls, the conduit for the station cable shall be installed to a 4-gang box, with a single gang mud ring, flush with the surface of the wall where the bracket will be installed.
2. For existing walls, the conduit for the station cable shall end directly into the side of the bracket, with a bushing on the end. A larger knockout shall be cut into the bracket by the Contractor.

D. For ceiling mounted wireless APs on hard deck ceilings, install a Wireless Surface Enclosure with the door facing down.

1. For new ceilings, the conduit for the station cable shall be installed to a 4-gang box, with a single gang mud ring, flush with the bottom surface of the hard deck ceiling where the enclosure will be installed.
2. For existing ceilings, the conduit for the station cable shall end directly into the side of the enclosure, with a bushing on the end.

E. For outdoor wireless antennas, install a Wireless Surface Enclosure on the inside of the exterior building wall, and a weatherproof outdoor rated electrical box with a cover on the outside of the wall.

1. A 1-1/2" conduit shall be installed through the exterior wall to connect the boxes. The Wireless Surface Enclosure shall be positioned so that the 1-1/2" conduit enters close to the side of the enclosure where it will be accessible for the coaxial antenna cables to feed through.

F. Install enclosures for wireless AP equipment, including all accessories and firestop materials, in accordance with manufacturer's specifications.

SECTION 27 08 00

COMMUNICATIONS SYSTEMS COMMISSIONING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD IT Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section

1.02 IDENTIFICATION

A. The Contractor shall ensure that all personnel, including subcontractors and their personnel, wear RTD issued identification badges. Jackets and/or shirts with company names and logos are helpful, but all workers are required to obtain and display the required RTD issued ID. Badges will be authorized by the RTD project manager.

B. Equip all vehicles with signs identifying the Contractor company. All vehicles used at RTD by Contractor personnel, whether owned by the employee or the Contractor, shall have visible company identification on both sides of the vehicle. Magnetic signs are acceptable.

1.03 CONTRACTOR RESPONSIBILITY FOR CONDUCTING BACKGROUND CHECK

A. All employees of the Contracting firm must pass a background check using a national criminal database standard for the industry.

B. Contractors are solely responsible for conducting background checks on all employees, agents, and subcontractors that provide services to RTD and certifying that such employees and agents have satisfactorily completed the background check. It is expected that background checks would be reviewed and cleared on a case by case basis for the following at a minimum:

1. Not a registered sex offender
2. No convictions (felony or misdemeanor) in the past 3 years for drug use/distribution
3. No convictions (felony or misdemeanor) in the past 3 years for serious or violent crimes, including but not limited to homicide or sexual assault
4. No convictions (felony or misdemeanor) in the past 3 years for theft or destruction of property

1.04 DELIVERY AND STORAGE

A. Make provisions for the delivery and safe storage of all materials and equipment. Specific delivery and storage instructions to be coordinated between RTD and Contractor in advance.

B. Mark materials and store in such manner as to be easily checked and inspected.

C. Store all materials and equipment out of the weather and protected from damage, theft, and vandalism and assume complete responsibility for losses due to any cause. Store materials on dry base at least 6" above ground or floor and provide waterproof covering. Remove and provide special storage for items subject to moisture damage. Replace items stolen or damaged at no cost to RTD.

D. Equipment or materials stored on site shall be stored so as not to interfere with other work, block passageways, or obstruct access/exits to buildings or facilities.

E. Where materials are indicated to be furnished by other or by RTD for installation under this Division, make a complete and careful check of all materials delivered and furnish a receipt acknowledging acceptance of the delivery and condition of the materials delivered. After such acceptance, assume full responsibility for their safe keeping until such time as the completed installation has been accepted.

F. Use of trailers may be required. Coordinate with RTD for location of any required trailers.

G. Contractor shall be responsible for all costs associated with materials and equipment delivery and storage.

1.05 SITE ACCESS AND COORDINATION WITH OCCUPANTS

A. Contractor shall have access to site during normal business hours subject to any work restriction for the duration of the project.

1. Contractor must comply to platform restrictions during rush hours.

B. Perform work in a manner so as to minimize disruption to the ongoing day-to-day activities of the occupants of the facility.

C. Notify RTD to schedule activities that may disrupt the occupants.

D. There are areas of the buildings/Platforms where access is restricted or regulated for personnel safety. RTD will identify such sensitive work areas in which advanced scheduling and admittance permission is required.

E. Doors to Telecom Rooms, Equipment Rooms, and Comm Huts shall be closed and secured at all times when unattended.

1.06 SITE RESTORAL AND CLEANUP

A. Keep the buildings, premises and surrounding areas free from accumulation of surplus, waste materials or rubbish caused by operations at all times.

B. Remove tools, equipment and scaffolding, and leave the area where the work has been done clean at the end of each workday. In the case of dispute, RTD may remove all such items and charge the cost of such removal to the Contractor.

C. Before leaving each day, remove all surplus material, waste material, empty boxes, crates, and rubbish, and transport rubbish to an off-site location, unless an on-site location for waste disposal is designated by RTD.

D. Keep clean all equipment and fixtures for the duration of the project.

E. Upon completion of work and before acceptance, remove from the site all surplus and discarded materials, temporary structures, tools, and debris. Surplus and waste materials removed from the site shall be disposed of in accordance with applicable laws and regulations.

F. Equipment shall be turned over to RTD in perfect, unblemished condition.

G. Replace, restore, or bring to original condition any damaged floors, ceilings, walls, furniture, grounds, pavement, etc., caused by Contractor personnel and operations. Restore damage or disfigurements and repair surfaces, including finish and/or paint, to match existing.

H. Upon completion of work and before acceptance, thoroughly clean the entire work area including all equipment and fixtures, both exposed surfaces and interiors. Final cleanup at job completion shall include:

1. Exterior: In addition to items specified below, any new surfaces on exterior, concrete, metal, etc. shall be carefully and thoroughly cleaned.

2. Hardware: Clean and polish all hardware and leave clean and free from paint, grease, dirt, etc.

3. Electrical: Clean and polish all electric fixtures, including glassware, switch plates, etc. and leave clean and free from paint, grease, dirt, etc.

4. Equipment: Carefully and thoroughly clean all items of equipment, mechanical, electrical, cabinets, ductwork, etc.

5. Floors: Thoroughly clean all floors. Vacuum and clean all carpeting. Sweep all hard surface floors.

I. Leave the site in a clean, neat, and orderly condition at least equal to that which originally existed. All final cleanup of the exterior and interior of the building shall be done by the Contractor or by professional cleaners hired and paid for by the Contractor as required.

SECTION 27 08 10

OPTICAL FIBER TESTING AND MEASUREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, Conditions of the Contract, including Construction Manager/General Contractor (CM/GC) Agreement, Exhibits and other Specification Sections that apply to this section.

1. Section 27 17 00 - TESTING, IDENTIFICATION AND ADMINISTRATION

1.02 SCOPE OF WORK

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete and proper test measurements of the installed optical fiber cabling.

B. In order to conform to the overall project event schedule, the contractor shall survey and coordinate the optical fiber testing with other applicable trades and RTD IT.

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

D. The contractor shall provide all test measurement results two (2) weeks prior to substantial completion in manifest spreadsheet format and native file format from the test instrument. Software shall also be provided to view the native results.

1.03 SCOPE

A. Test measurements shall be carried out in accordance with the Tier 2 specification of ANSI/TIA-568-C.0, Annex E, plus an image capture of connector end-faces. Tier 2 testing is a higher level of testing that provides qualitative measures of the installed condition and performance of the cabling system and its components. Tier 2 testing includes length measurement, attenuation measurement, verifying polarity (using an optical loss test set (**OLTS**) and obtaining a trace and event table of the fiber with an optical time domain reflectometer (**OTDR**). OTDR traces are used to evaluate the installed cabling for anomalies and assuring uniformity of cable attenuation and connector insertion loss.

B. Testing shall be performed on each optical fiber cabling link (adapter to adapter).

C. All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode (850nm and 1300nm) and singlemode links (1310nm and 1550nm), OLTS length measurements for multimode and singlemode links, OTDR traces and event tables for multimode and singlemode links, and image captures of connector end-faces.

1.04 DEFINITIONS

A. Optical fiber cabling link: A fiber with an adapter on each end.

1.05 QUALITY ASSURANCE

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

1. ANSI Z136.2, ANS for Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources
2. ANSI/EIA/TIA-455-50B, Light Launch Conditions for Long-Length Graded- Index Optical Fiber Spectral Attenuation Measurements
3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.
4. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR.
5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.
6. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant.
7. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.

- 8. ANSI/TIA -568-C.0, Generic Telecommunications Cabling for Customer Premises.
- 9. ANSI/TIA -568-C.3, Optical Fiber Cabling Components Standard.
- 10. ANSI/TIA-942-A – Telecommunications Infrastructure Standard for Data Centers

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

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

C. The Owner or an RTD IT representative shall be invited to witness, review or both witness and review field-testing.

- 1. The Owner or RTD IT representative shall be notified of the testing start date, five (5) business days before testing commences.
- 2. The Owner or an RTD IT representative will select a random sample of 5% of the installed links and test that sample. The measured results obtained from the random sample shall be compared to the data provided by the contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the contractor under supervision of the Owner or an RTD IT representative shall repeat 100% of the testing at no cost to the Owner.

1.06 SUBMITTALS

- A.** Manufacturers catalog sheets and specifications for the fiber optic field-test instruments including optical loss test sets (OLTS), optical time domain reflectometer (OTDR) and end-face inspection capture device.
- B.** A schedule (list) of all optical fibers to be tested identified per RTD IT specifications.
- C.** Sample test reports.

1.07 ACCEPTANCE OF TEST RESULTS

- A.** Link attenuation measurement and allowance calculation
 - 1. The measured link attenuation shall be less than the link attenuation allowance.
 The link attenuation allowance is calculated as:

$$\text{Link Attenuation Allowance (dB)} = \text{Cable Attenuation Allowance (dB)} + \text{Connector Insertion Loss Allowance (dB)} + \text{Splice Insertion Loss Allowance (dB)}$$

where:

$$\text{Connector Insertion Loss Allowance (dB)} = \text{Number of Connector Pairs} \times 0.4\text{dB}$$

$$\text{Splice Insertion Loss Allowance (dB)} = \text{Number of Splices} \times 0.15\text{dB}$$

$$\text{Cable Attenuation Allowance (dB)} = \text{Maximum Cable Attenuation Coefficient (dB/km)} \times \text{Length (km)}$$

Optical fiber cable attenuation performance

Optical fiber and cable type ²	Wavelength (nm)	Maximum attenuation (dB/km)
62.5/125 μm Multimode (OM1)	850	3.5
	1300	1.5
50/125 μm Multimode (OM2)	850	3.5
	1300	1.5
850 nm Laser-Optimized 50/125 μm Multimode (OM3)	850	3.5
	1300	1.5
Single-Mode Indoor-Outdoor (OS1) (OS2)³	1310	0.5
	1550	0.5
Single-Mode Inside Plant (OS1) (OS2)³	1310	1.0
	1550	1.0
Single-Mode Outside Plant (OS1) (OS2)³	1310	0.5
	1550	0.5

B. All installed cabling links shall be field-tested and pass the link attenuation measurement and allowance calculation and OTDR analysis. Any optical fiber link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.

C. Individual connector, splice and fiber insertion loss shall be evaluated using the OTDR trace. These components shall meet or exceed the values in 1.07, A.

PART 2 - PRODUCTS

2.01 OPTICAL FIBER CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer.

B. The field-test instrument shall contain the most recent software and firmware provided by the manufacturer prior to testing.

C. Optical loss test set (OLTS)

1. The OLTS shall be capable of providing length measurement of the fiber under test.
2. Multimode optical fiber light source
 - a. Provide dual LED light sources with central wavelengths of 850 nm (± 30 nm) and 1300 nm (± 20 nm)
 - b. Output power of -20 dBm minimum.
 - c. The light source shall meet the launch requirements of ANSI/EIA/TIA-455-50B, Method A. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap with a Category 1 light source.
3. Singlemode optical fiber light source
 - a. Provide dual laser light sources with central wavelengths of 1310 nm (± 20 nm) and 1500 nm (± 20 nm).
 - b. Output power of -10 dB minimum.
4. Power Meter
 - a. Provide 850nm, 1300nm and 1500nm wavelength test capability.
 - b. Power measurement uncertainty of ± 0.25 dB.
 - c. Store reference power measurement.
 - d. Save at least 100 results in internal memory.
 - e. PC interface (serial or USB).
5. Acceptable manufacturers, models:
 - a. Fluke Networks, OptiFiber (OLTS and OTDR combined)
 - b. Fluke Networks, DTX (OLTS; MFM2, SFM2)
 - c. Corning Cabling Systems OTS-613QD (OLTS)
 - d. Exfo, FOT-600 OLTS (OLTS)
 - e. Approved equivalent

D. Optical Time Domain Reflectometer (OTDR)

1. Shall have a bright, color transmissive LCD display with backlight.
2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
3. Internal non-volatile memory and removable memory device with at least 16 MB capacity for results storage.
4. Serial and USB ports to transfer data to a PC.
5. Multimode OTDR
 - a. Wavelengths of 850 nm (± 20 nm) and 1300 nm (± 20 nm).
 - b. Event dead zones typically of 0.5 m at 850 nm and 1.3 m at 1300 nm.
 - c. Attenuation dead zones 4.5 m at 850 nm and 10.5 m at 1300 nm.
 - d. Distance range 3 km at 850 nm and 7 km at 1300 nm.
 - e. Dynamic range 15 dB at 850 nm and 14 dB at 1300 nm.
6. Single-mode OTDR

- a. Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).
- b. Event dead zones typically of 1 m at 1310 nm and 1 m at 1550 nm.
- c. Attenuation dead zones typically of 8 m at 1310 nm and 8 m at 1550 nm.
- d. Distance range at least 60 km.
- e. Dynamic range 26 dB at 1310 nm and 24 dB at 1550 nm.

7. Acceptable manufacturers, models:

- a. Fluke Networks, OptiFiber (OLTS and OTDR combined with end face image capture)
- b. Fluke Networks, DTX (QUAD-OTDR)
- c. Corning Cabling Systems, OV-1000 OTDR
- d. Exfo, FTB-150 OTDR
- e. Approved equivalent

E. Fiber Microscope

- 1. Magnification of 250X or 400X for end-face inspection
- 2. Video camera and display showing magnified end-face image.
- 3. Camera probe tips permitting inspection through adapters.
- 4. Capable of saving end-face image.
- 5. Acceptable manufacturers, models:
 - a. Corning Cabling Systems, VIP-CCO-K17
 - b. Fluke Networks, Opti Fiber (OLTS and OTDR combined with end face Image capture)
 - c. Approved equivalent

F. Administration

- 1. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
- 2. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

PART 3 - EXECUTION

3.01 GENERAL

- A.** All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2. **NOTE** – A visible fault locator (VFL) normally uses a Class 2 or 3 light source and should not be directly viewed. Safe usage of the tool requires indirect viewing of the light source by pointing the end of the fiber at an adjacent surface (or introducing another surface in front of a fixed mounted connector) until the presence of light is determined.
- B.** All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
- C.** Dust caps shall be placed on fiber end-faces or adapters for each optical fiber link after all testing is complete on the fiber link.
- D.** Testing shall be performed in accordance with ANSI/TIA-568-C.0 Annex E, Tier 2 testing on each cabling segment (i.e., verify polarity, measuring length, OLTS attenuation measurement, and OTDR trace).
- E.** In addition to Tier 2 testing of ANSI/TIA-568-C.0 Annex E, an image of each fiber optic connector end-face shall be taken, recorded and provided as part of the records.
- F.** Optical fiber link test results from the OLTS, OTDR and end-face image shall be recorded in the memory of the field-test instrument.
- G.** Each optical fiber test shall be uploaded to a PC in which the administrative documentation (reports) shall be generated.
- H.** The records for each test shall be provided to the owner a minimum of two weeks prior to substantial completion in Excel format and the native format to the test instrument.

3.02 OPTICAL FIBER TESTING

- A.** Polarity

1. For duplex connector systems, polarity shall be verified. The polarity shall be verified with an OLTS while performing attenuation tests.

B. Length measurement

1. Each optical fiber link shall be measured for its length. The fiber length may be obtained by a capable OLTS or by an OTDR.

C. Attenuation measurement (OLTS)

1. General

- a. Optical sources shall be turned on for a minimum of 5 minutes prior to referencing.
- b. Test jumpers shall be reference quality and between 1m and 5m in length.
- c. Mandrels shall be used when testing attenuation of multimode optical fiber cabling with an OLTS. The mandrel sizes are shown in the following table

Fiber core/cladding size (µm)	900 µm buffered fiber (mm)	2.0 mm jacketed cable (mm)	2.4 mm jacketed cable (mm)	3.0 mm jacketed cable (mm)
50/125	25	23	23	22
62.5/125	20	18	18	17

d. Where mandrels are used, secure the mandrel to the light source by some means such as a cable tie or tape. Care should be taken to ensure that the fiber jacket is not deformed or damaged when using a cable tie or tape.

e. The light source shall be referenced to the meter a minimum of twice daily (i.e., in the morning and noon).

f. Fiber test jumpers shall be of the same core size as the cabling under test (e.g., singlemode to singlemode, 62.5µm multimode to 62.5µm multimode, 50µm multimode to 50µm multimode). Additionally, the test jumpers shall meet the performance specifications of the fiber under test and that of the test instrument manufacturer.

g. Fiber test jumpers shall be cleaned prior to connection to the test instrument. After cleaning, cleaning solutions shall be given sufficient time to evaporate (approximately 30 seconds) prior to the mating of fiber test jumper to the test instrument.

h. The end of the fiber test jumper that will connect to the fiber link to be tested, the adapters and fiber under test shall be cleaned immediately prior to each fiber being tested. After cleaning, cleaning solutions shall be given sufficient time to evaporate (approximately 30 seconds) prior to the mating of fiber test jumper to the fiber under test.

i. The test jumper connected to the source shall not be removed after referencing so as not to adversely influence the attenuation measurement. Removal and reattachment of the test jumper connection from the source may affect the referenced power level. Re-referencing is to be performed if the test jumper is disconnected from the light source.

j. Singlemode optical fiber links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper.

k. Multimode optical fiber links shall be tested at 850 nm and 1300 nm in accordance with ANSI/TIA/EIA-526-14-A, Method B, One Reference Jumper.

l. Multimode and singlemode optical fiber links shall be measured and reported for attenuation in each direction and attenuation bi-directionally (averaged in both directions). The measurements shall be less than or equal to the link attenuation allowance calculation (see Part 1, 1.07, A.).

2. Steps to measure and calculate optical fiber link attenuation include

- a. verifying test jumper quality.
- b. setting the reference.

- c. measuring link attenuation; and
- d. calculating link attenuation.

3. This example below describes the process when testing multimode fiber with the test jumper connected to the source having five non-overlapping wraps of multimode fiber on a mandrel. The procedure is also applicable to single-mode cabling, however, the five non-overlapping wraps of multimode fiber would be replaced with a single 30 mm (1.2 in) diameter loop of single-mode fiber.

a. Verifying test jumper quality

- i. Test jumpers shall be tested for quality prior to use as a test jumper. See example below.

To verify that the test jumpers are in acceptable condition, first reference the light source to the optical power meter (see figure 1). Disconnect test jumper (J1) from the power meter (only) and insert a second test jumper (J2) by connecting it to the power meter and to (J1) with a mating adapter (see figure 2) and record the measurement. Disconnect both ends of J2, interchange the ends, and reconnect it and record the measurement. The resulting measurements, P_{verify} , should be within the appropriate connector loss specification. For example, if the connector used is specified at 0.32 dB, the reading on the power meter should be within 0.32 dB of P_1 .

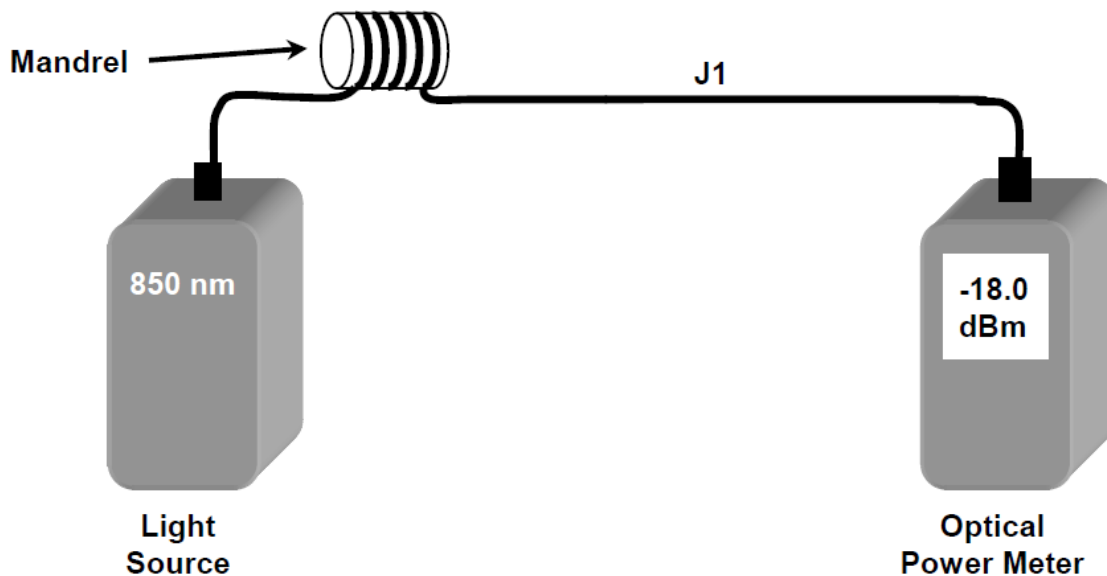


Figure 1 – Example of OLTS reference measurement (P_1) with one test jumper (multimode)

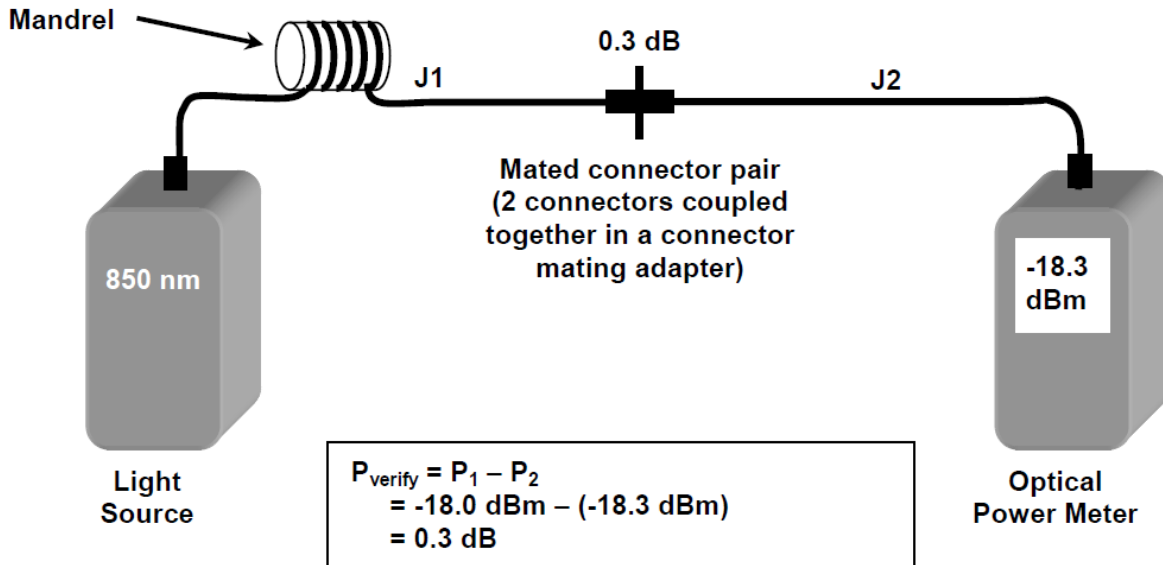


Figure 2 – Example of a measurement (P_2) when verifying OLTS test jumpers (multimode)

b) Setting the reference

- i. One test jumper (J1) is to be connected between the light source and the power meter and a reference measurement taken (P_1 [dBm]). When testing a multimode optical fiber link, a mandrel wrap shall be applied to the test jumper (J1) prior to setting the reference and for all subsequent measurements.

When testing a singlemode optical fiber link, a single 30 mm (1.2 in) diameter loop shall be applied to the test jumper (J1) prior to setting the reference and for all subsequent measurements.

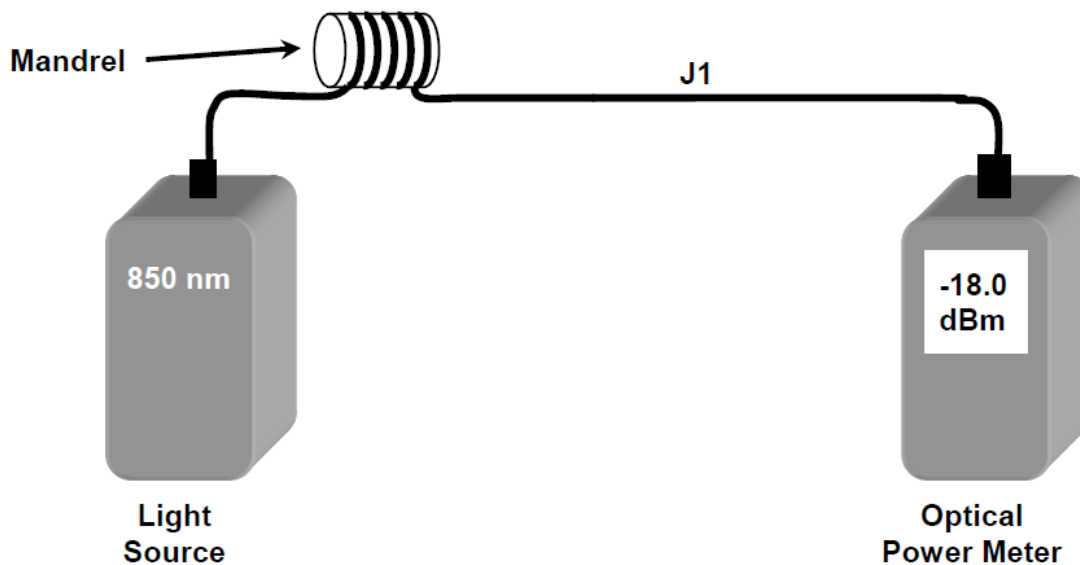


Figure 3 – Example of OLTS reference measurement (P_1) with one test jumper (multimode)

c. Measuring link attenuation

- i. Connect the end of test jumper (J1) (source end) to one end of the link and connect and verified test jumper (J2) between the other end of the link and the meter (see figure 4). The optical power reading is P_2 (dBm).

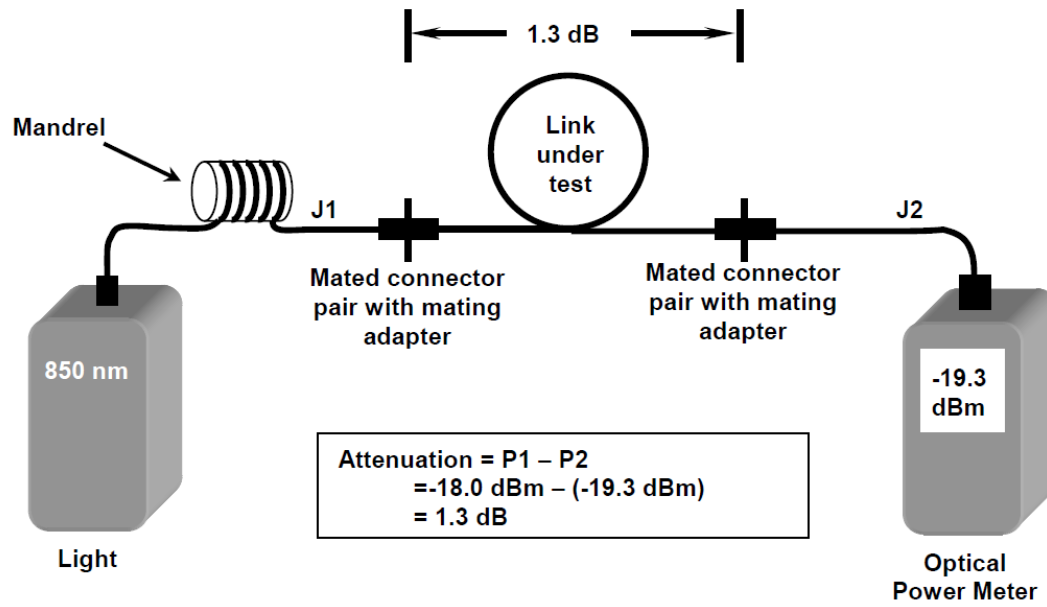


Figure 4 – Example of a multimode link attenuation measurement (P_2)

d. Calculating link attenuation Link attenuation shall be calculated by the OLTS. Calculated optical fiber link attenuation is applied by using the following equation.

$$\text{Attenuation dB} = P_1 \text{ dBm} - P_2 \text{ dBm}$$

where:

P_1 = Reference power measurement

P_2 = Cabling test power measurement

3. Link attenuation measurement and allowance calculation

a. The measured link attenuation shall be less than the link attenuation allowance (see Part 1, 1.07, A.).

D. Optical fiber end-face image

1. An image of each optical fiber end-face shall be taken and recorded after Tier 2 testing of the optical fiber link is completed. The end-face image shall be captured at either 250X or 400X.

E. OTDR trace

1. An OTDR trace shall be taken of each optical fiber link in one direction to ensure uniformity of cable attenuation and connector insertion loss. Multimode fiber traces shall be taken at 850nm and 1300nm. Singlemode fiber traces shall be taken at 1310nm and 1550nm.

2. A launch cable to the length specified by the manufacturer of the OTDR shall be installed between the OTDR and the first link connection. The launch cable shall be of the same fiber type as the link under test.

3. A receive cable shall be installed after the last link connection to be part of the OTDR trace. The receive cable shall be at least 100m (328ft) in length and of the same fiber type as the link under test.

4. Selectable parameters affecting the OTDR measurement may include the test source wavelength, pulse duration or signal strength, length range, backscatter coefficient, signal averaging (time or count) and the group index of the fiber (also known as the index of refraction or the refractive index). The display shall be adjusted to view the region of interest on the trace on both the horizontal and vertical axes.

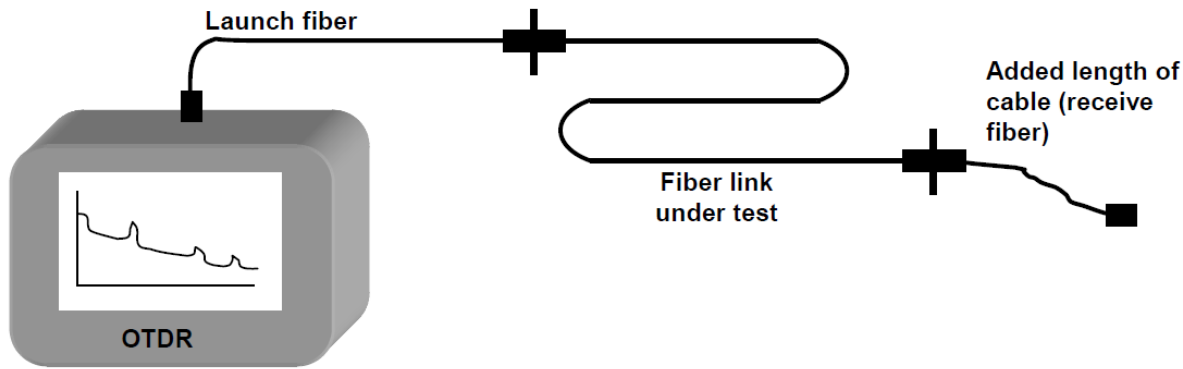


Figure 5 – OTDR setup illustration of fiber link testing

3.03 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”.
2. The test results documentation shall be available for inspection by the Owner or an RTD IT representative during the installation period. The contractor shall retain a copy to aid preparation of as-built information.
3. The records for each test shall be provided to the owner a minimum of two weeks prior to substantial completion in Excel format and the native format to the test instrument.
4. Circuit IDs reported by the field-test instrument shall match the label ID specified by the Owner.
5. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information
 - a. The identification of the customer site as specified by the end-user
 - b. The name of the standard selected to execute the stored test results
 - c. The name of the test personnel
 - d. The date and time the test results were saved in the memory of the tester
 - e. The manufacturer, model and serial number of the field-test instrument
 - f. The version of the test software and the version of the test standards database held within the test instrument
 - g. The value of the ‘index of refraction’ used for length calculations
 - h. The fiber identification number
 - i. The length for each optical fiber calculated by the OLTS.
 - j. Test results to include OLTS attenuation link and channel measurements at 850 nm and 1300 nm for multimode cabling, and at 1310 nm and 1550 nm for singlemode cabling and the margin (difference between the measured attenuation and the test limit value).
 - k. Test results shall be submitted to include OTDR link and channel traces and event tables at 850 nm and 1300 nm for multimode cabling, and at 1310 nm and 1550 nm for singlemode cabling and the margin (difference between the measured attenuation and the test limit value).
 - l. The length for each optical fiber calculated by the OTDR.
 - m. The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
 - n. A picture or image of each fiber end-face

SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOM WORK

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section

1.02 SCOPE OF WORK

A. Provide all services, labor, materials, tools, and equipment required for the complete and proper installation within the Telecommunications Rooms (TRs), Equipment Rooms (ERs) and Communication Huts/Cases (Comm Hut) as called for in these specifications and related drawings.

B. This section includes minimum requirements and installation methods for the following:

1. Equipment Racks and Cable Routing Hardware
2. Copper Termination Equipment
3. Fiber Termination Equipment
4. Coaxial Termination Equipment
5. Grounding and Bonding

1.03 QUALITY ASSURANCE

A. All installation work in the TRs, ERs and the Comm Huts shall be performed in a neat and skillful like manner. All methods of construction that are not specifically described or indicated shall be subject to the control of RTD.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval of RTD based on submittals provided.

1.04 ARCHITECTURAL AND COMMUNICATION DESIGN REQUIREMENTS

A. New Telecommunications Rooms (TRs), Equipment Rooms (ERs) and Communication Huts/Cases (Comm Huts) shall be designed in compliance with the space, electrical, and environmental requirements of ANSI/TIA-569-D – Commercial Building Standard for Telecommunications Pathways and Spaces. Smaller spaces or enclosures shall not be acceptable without prior written approval from RTD IT.

B. If any DAS equipment is to be located within the TRs, ERs, and Comm Huts, the space and environmental requirements for these rooms will be revised to accommodate this additional equipment without impacting the RTD IT equipment in these rooms. The TRs, ERs, and Comm Huts designs shall be coordinated between the telecommunications low-voltage consultant and the DAS consultant.

C. The TRs, ERs, and Comm Huts designs for Consultant Designed projects shall comply with the RTD IT requirements

D. The hardware layout in the racks shall follow the RTD standard format from top to bottom and left to right as shown in the typical rack layout drawings.

E. Corridor access with the door to swing out is required for all new TRs, ERs, and Comm Huts, which shall comply with common area access requirements. No other rooms shall lead directly to or from the TR, ER or Comm Hut.

F. All walls of the TRs, ERs, and Comm Huts shall be covered with rigidly fixed $\frac{3}{4}$ " A-C fire-resistant or non-combustible plywood backboard, void free, 8' high, painted with two coats of white colored fire-retardant paint. The bottom edge of the plywood shall be 4" above the floor.

G. The TRs, ERs, and Comm Huts shall be open to the structure above (no suspended ceiling).

- H.** The floor, walls and ceiling of the TRs, and ERs will be sealed to reduce dust. The floor shall be sealed concrete.
- I.** The communication TRs, ERs, and Comm Huts cannot be shared with other departments or purposes including, but not limited to, custodial, electrical, mechanical, storage, etc.
- J.** Equipment not related to the support of the TR, ER, and Comm Hut (e.g., piping, ductwork, pneumatic piping, electrical equipment, plumbing, etc.) should not be installed in, pass through, or enter the room.
- K.** No equipment, hardware, piping, etc. shall be added in or near any TR, ER, or Comm Hut that will change the Temperature or humidity of these rooms without written agreement from RTD IT department prior to design and installation.
- L.** New TRs, ERs, and Comm Huts shall not be adjacent to any electrical room or room containing a transformer or motors. Electrical power systems in or adjacent to the TRs, ERs, and Comm Huts should be configured such that their electromagnetic fields do not interfere with telecom cabling or equipment.
- M.** All TRs, ERs, and Comm Huts shall be secure with all walls from floor to the ceiling structure. In the event of extra high ceilings, a hard ceiling can be added to these rooms with RTD IT prior written approval.

1.05 MECHANICAL, ELECTRICAL AND PLUMBING REQUIREMENTS

- A.** Mechanical, electrical and plumbing systems within new TRs and ERs shall be designed in compliance with the requirements of ANSI/TIA-569-D.
- B.** The communication TRs, ERs, and Comm Huts cannot be shared with other departments or purposes including, but not limited to, custodial, electrical, mechanical, plumbing, storage, etc.
- C.** Equipment not related to the support of the TR, ER, or Comm Hut (e.g., piping, ductwork, pneumatic piping, electrical equipment, plumbing, etc.) shall not be installed in, pass through, or enter the room.
- D.** No equipment, hardware, piping, etc. shall be added in or near any TR or ER that will change the temperature or humidity of these rooms without written agreement from RTD IT department prior to design and installation.
- E.** Power for all TRs, ERs, and Comm Huts in the building shall be provided by a separate supply circuit terminated on its own electrical panel with an isolated ground. This electrical panel shall be located in the room with the Main Distribution Frame (MDF). If the building is equipped with a standby power generator, the panel serving the TRs, ERs, and Comm Huts shall be connected to the standby power generator.
 - 1. Each equipment rack shall have at minimum, one (1) dedicated 120V, 20A, non-switched, ac quad electrical receptacle, each on a separate branch circuit, installed in the bottom of each equipment rack to support rack-mounted uninterruptible power supply(s) (UPS). In addition, at minimum a dedicated 208V/20A, NEMA L6-20 receptacle shall be mounted adjacent to the above described 120V receptacle. The final size and type of UPS may affect the exact electrical receptacle type required. Designer shall coordinate this with RTD IT early in the design phase. Up-size electrical wiring to support at minimum 30 amps to allow the flexibility to up-size outlets in the future.
- F.** Power for telecommunications and data network equipment in the TRs, ERs, and Comm Huts shall be provided by installing the following for every two racks installed at 7'6" AFF: two (2) 5-20R double duplex outlets with a dedicated 120VAC, 20A circuit; one (1) L530R outlet with a dedicated 120VAC, 30A circuit plus one additional 30A 208V/1-phase receptacle per three racks minimum. In addition, convenience 5-20R duplex power outlets should be placed on the walls of the TRs, ERs, and Comm Huts.
- G.** Lighting in the TRs, ERs, and Comm Huts shall be a minimum of 500 lx (50-foot candles) measured 1 m (3 ft.) above the finished floor, mounted 2600 mm (8.5 ft.) minimum above the finished floor. Lighting fixtures shall not be powered from the same electrical distribution panel as the telecom or data equipment in the room.
- H.** New TRs and ERs shall not be adjacent to any electrical room or room containing a transformer or motors. Electrical power systems in or adjacent to the TRs, ERs, and Comm Huts should be configured such that their electromagnetic fields do not interfere with telecom cabling or equipment.
- I.** No liquid piping, dry liquid piping, drains or steam piping shall pass through or within the walls of any TRs, ERs, and Comm Huts with the exception of fire safety systems, nor locate any areas directly above the TR, or ER where water service may be provided.

J. No equipment, hardware, piping, etc. shall be added in or near any TR, ER, or Comm Hut that will change the temperature or humidity of these rooms without written agreement from RTD IT department prior to design and installation.

K. Environmental control HVAC systems shall be provided for the TRs, ERs, and Comm Huts so that the temperature in These rooms will meet the requirements for ASHRAE Class B. The HVAC systems shall be provided to maintain a continuous operational range of 41°F to 90°F, with the maximum design load provided by the low-voltage consultant and approved by RTD IT. A positive pressure differential with respect to surrounding areas shall be provided. If a standby power source is available in the building, the HVAC system serving the TRs, ERs, and Comm Huts should be connected to the standby power.

L. The maximum HVAC loads (BTU/Hr) and power consumption (Watts) for the TRs, ERs, and Comm Huts shall be determined by the telecommunications low-voltage consultant as specified. If any DAS equipment is to be located within the TRs, ERs, and Comm Huts, additional HVAC loads (BTU/Hr) and power consumption (Watts) for this equipment shall be provided by the DAS Consultant, as specified.

PART 2 – MATERIALS

2.01 EQUIPMENT AND MATERIALS MINIMUM REQUIREMENTS

A. Floor-Mount Equipment Rack

1. Standard 19" rack mounting space and accommodate Slides or rails for servers and follow the EIA-310-E standard.
2. 84" high with 42U rack spaces (1 rack space = 1- $\frac{3}{4}$ ") and 4 post configurations
3. EIA-310-D standard 5/8" 5/8" 1/2" hole pattern
4. EIA channel width of 3" with double-sided tapped screw holes
5. Lightweight high strength aluminum construction with Black or clear finish
6. 15" deep base with four (4) $\frac{3}{4}$ " bolt down holes and equipped with hardware for permanent mounting on concrete floor
7. Rack installation kit
8. Dust covers for the base of all racks.
9. 1000 lb standard for the Main Distribution Frame (MDF) and Intermediate Distribution Frame (IDF) in the TRs, ERs, and Comm Huts, or 1500 lb for data centers, as required.

B. Vertical Rack Cable Management (for new installations)

1. 84" high
2. Slack Loop Storage Organizer, Extended (2") Mounting Bracket
3. Cable Retainer Cover

C. Rack Cable Management and Accessories

1. Interbay Cable Organizer
2. Screw-Mount, Reusable Cable Ties
3. Cable Runway Rack Elevation Kit – Cable Runway Support (stiff leg)
4. Rack to Runway Mounting Plate – (stiff leg)

D. Power Strips

1. Standard 19" rack-mount power strip with 10 outlets and 10' cord

E. Ladder Cable Runway

1. Tube steel painted Gray with cross members welded at 12" intervals: 6", 12", 18" and 24" wide with lengths as required.
2. Alternate Space Cable Runway for over Equipment Racks – Gray 12" W x 1.5"H x 8.73'L with cable capacity 629.
3. Cable Runway Radius Drops for cross members and stringers: 6", 12", 18" and 24" wide.
4. Include support kits, brackets, splice kits, end caps, etc. as required for complete installation.

F. Plywood Backboard: $\frac{3}{4}$ " A-C fire-resistant or non-combustible plywood backboard, void free, 8' high, painted with two coats of white fire-retardant paint.

G. $\frac{1}{2}$ " D-Rings and D-Rings wall-mount nominal 2" 4" or 6" as required.

H. Velcro cable ties for cable routing and management as required. Various lengths to ensure a minimum 2" overlap when wrapped around the cable.

2.02 COPPER TERMINATION EQUIPMENT

- A. Category 3 – For Renovations Match Existing and for Additions use 66-type connecting blocks and brackets:
 1. 66 block punch down 66M1-50 style
 2. 89 bracket
 3. 66M cover
 4. Bridge clips
- B. Patch Panel: 24-port or 48-Port Rack Mount Panel – Unloaded
- C. Building Entrance Protector – Cat 3: 66 block punch to 66 block punch with 5 pin heat coil input.
- D. Building Entrance Protector Gas Tube and 4 ohms with 5 pin Heat Coils.
- E. Solid State Protector Modules: 18V, 27V, or 65V (for POE)

2.03 FIBER TERMINATION EQUIPMENT

- A. Rack-Mount Fiber Termination Shelves
 1. 4U Fixed Shelf for Backbone Cable
 2. 1U Sliding Shelf for Combination Station and Backbone Cable
- B. Fiber Termination Panels for Rack-Mount Shelves
 1. SC Duplex Adapter Panel for Singlemode Fiber
 2. SC Duplex Adapter Panel for Multimode Fiber
- C. Splice Kits and Wallets as required for fiber termination

2.04 COPPER PATCH CORDS

- A. Copper Category 6:
 1. Colored Black for Voice in TRs, ERs, and Comm Huts
 - a. One patch cord per voice jack
 - b. Lengths: 3' = 15%, 5' = 65%, 7' = 20%, unless otherwise specified
 - c. Field terminated patch cords are not acceptable.
 2. Colored Blue for Data in TRs, ERs, and Comm Huts
 - a. One patch cord per data jack
 - b. Lengths: 3' = 15%, 5' = 65%, 7' = 20%, unless otherwise specified
 - c. Field terminated patch cords are not acceptable.
 3. Special Circuit Cord Colored Yellow for Video - Quantity and length as specified for project
 - a. Field terminated patch cords are not acceptable.
- B. Voice Patch Cord from Patch Panel to 66 Blocks (solid not stranded):
 1. Colored Black for Voice in TRs, ERs, and Comm Huts
 - a. Field terminated patch cords are not acceptable.
- C. Special Circuit Patch Cord from Patch Panel to 66 Blocks (solid not stranded):
 1. Special Circuit Colored Yellow for Video
 - a. Field terminated patch cords are not acceptable.
- D. Copper Category 6A for Wireless projects – may also be specified for other projects with prior written approval from RTD IT
 1. Colored White for Data in TR, ER, and Comm Hut
 - a. One patch cord per Wireless Access Point (AP) location, unless otherwise specified
 - b. One patch cord per data jack for other projects (non-Wireless)
 - c. Lengths: 3' = 10%, 5' = 70%, 7' = 10%, 10' = 10%, unless otherwise specified
 - d. Field terminated patch cords are not acceptable.
 2. Wireless AP Cord – Colored White

- a. One patch cord per Wireless AP location, unless otherwise specified
 - b. Length: 1'
 - c. Field terminated patch cords are not acceptable.
3. Desktop Mounting Cord for other projects (non-Wireless) – Colored White
- a. One patch cord per data jack
 - b. Length 10'
 - c. Field terminated patch cords are not acceptable.

2.05 GROUNDING AND BONDING

- A.** #4 and #6 AWG wire suitable for grounding application.
- B.** All connectors and clamps shall be mechanical type made of silicon bronze.
- C.** Terminals shall be solderless compression type, copper long-barrel NEMA two bolt.
- D.** Telecommunications Bonding Backbone (TBB): Minimum No. 6 AWG insulated copper conductor.
- E.** Telecommunications Grounding Busbar (TGB): Minimum 6 mm thick x 50 mm wide predrilled copper busbar with standard NEMA bolt hole sizing and spacing
- F.** All grounding equipment shall be UL listed for that purpose.

PART 3 - EXECUTION

3.01 EQUIPMENT RACKS AND CABLE ROUTING HARDWARE IN TELECOMMUNICATIONS ROOMS

- A.** The Telecommunications Rooms (TRs), Equipment Rooms (ERs), and Communication Huts/ Cases (Comm Huts) 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 in place will be shown on the project drawings.
- B.** Examine TRs, ERs, and Comm Huts and verify 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 of installation in the TRs, ERs, and Comm Huts indicates Contractor acceptance of existing conditions.
- D.** Install new equipment racks with all related mounting hardware, vertical and horizontal cable management and power strips in the TRs, ERs, and Comm Huts as required for project and as shown on drawings. Letter designation for racks and equipment shall be placed in the rack layout and in the panel details. All equipment racks shall be securely anchored to the concrete floor using minimum 3/8" hardware or as specified by rack manufacturer.
- E.** Install new ladder cable runway with all related mounting hardware for cable routing in the TRs, ERs, and Comm Huts as required for project and as shown on drawings. All ladder cable runway shall be securely anchored 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 the walls in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings. All plywood backboard shall be securely anchored to the walls and shall meet RTD IT requirements
- G.** Install D-rings on plywood backboard for cable routing in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings.
- H.** Equipment placement shall be coordinated with RTD IT staff.
- I.** Voice riser patch cords being installed to jacks on patch panels must not cross the center of the patch panel.
- J.** A small drip loop on the patch cords and horizontal cable is required for trouble shooting and tracing patch cords.
- K.** All patch cords and horizontal cables leaving the equipment racks shall have Velcro cable ties placed on the bundle every 8 to 12 inches within the TRs, ERs, and Comm Huts. The Velcro cable ties shall overlap a minimum of 2" to allow for more cable to be added in the future.

3.02 COPPER TERMINATION EQUIPMENT

- A. Some copper termination equipment may already be in place in existing TRs, ERs, and Comm Huts and will be shown on the project drawings.
- B. Mount new 66M1-50 blocks on 89B brackets for backbone and horizontal telephone cables directly on plywood backboard in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings. Add bridge clips, cross-connects, and patch cords for all voice installs in IDF TRs prior to final testing for projects and after testing for daily installs, and place new clear covers after cable termination and labeling.
- C. Mount new unloaded patch panels for horizontal cables in the floor-mounted equipment racks in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings.
- D. Label all copper terminations according to RTD IT standards. A one-page Copper Termination sheet, with backbone cable numbering for each TR, ER, and Comm Hut, will be provided by RTD IT. All labels shall be supplied and installed by the Contractor.
- E. Provide the copper patch cords for the ER/TR/Comm Hut, and the desktop mounting cords, to RTD IT twelve (12) weeks prior to final acceptance for all Consultant Designed projects. The quantity, color, and length of patch cords and desktop mounting cords shall be as specified herein, unless specified differently for a specific project. The patch cords will be of adequate length to fit the rack layout without excessive loops. Coordinate the proportion of (data) versus (voice) patch cords with RTD IT prior to ordering the cords. The patch cords and desktop mounting cords will be installed by RTD personnel.
- F. The voice patch cords from the patch panel to the 66, or Krone blocks shall be installed as indicated on the drawings for In-House projects and daily work. One end of these voice patch cords shall be plugged into the patch panel and the other end punched down on the block. The Contractor shall submit the T-5 Jack Position sheet, identifying the riser pair count and the associated jack numbers, within one week of award for In-House projects. These voice patch cords shall be supplied and installed by the Contractor prior to testing. They will not be tested through but will be temporarily unplugged for testing of the station cabling. The riser pair count and jack numbers shall be shown on the as-built drawings.

3.03 FIBER TERMINATION EQUIPMENT

- A. Some fiber termination equipment may already be in place in existing TRs, ERs, and Comm Huts and will be shown on the project drawings.
- B. Mount new fiber termination shelves with associated splice kits and wallets, adapter panels, and couplings, in the floor-mounted equipment racks in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings.
- C. Mount new LIUs with associated splice kits and wallets, adapter panels, and couplings, on the walls in the TRs, ERs, and Comm Huts as required for the project and as shown on drawings.
- D. Label all fiber enclosures according to RTD IT standards. Fiber schematic sheets will be provided by RTD IT and installed by the Contractor.
- E. Ensure dust covers are in place on all couplings prior to final acceptance.

3.04 GROUNDING AND BONDING

- A. Mount new TGBs on plywood backboard in TRs as shown on project drawings. The location for the TGBs shall be coordinated with RTD IT.
- B. Mount new TMGB on plywood backboard in main ER as shown on project drawings. The location for the TMGB shall be coordinated with RTD IT.
- C. Install new TBB from the TMGB in the ER to the TGBs in the TRs and Comm Huts as shown on project drawings. Connect the TBB to the TMGB and TGBs in accordance with TIA-607 and NEC. All grounding conductors leaving the TRs, ERs, and Comm Huts shall be in a separate conduit from all communication cabling.
- D. Bond all metallic surfaces of new racks, ladder cable runway, and equipment in the TRs, ERs, and Comm Huts to the TGB or TMGB in the same room with #6 AWG grounding wire as straight as possible.
- E. Bond all metallic raceways (conduit, cable tray, etc.) entering the TRs, ERs, and Comm Huts to the TGB or TMGB in the same room with #6 AWG grounding wire as straight as possible.

F. All grounding items shall be installed in complete compliance with Division 16 – Electrical (or CSI 2004 Division 26 - Electrical) and NEC.

3.05 AS-BUILT DRAWINGS

A. Mark the project drawings with notations reflecting actual TR, ER and Comm Hut equipment placement and any variations from the base specifications and drawings.

B. Comply with **Construction Drawings AS-BUILT Requirements**.

SECTION 27 13 00

COMMUNICATIONS BACKBONE CABLING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD IT Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section

1.02 SCOPE OF WORK

A. Provide all services labor, materials, tools, and equipment required for the complete and proper installation, splicing, and termination of new backbone cabling as called for in these specifications and related drawings.

B. This section includes minimum requirements and installation methods for the following:

1. Copper Backbone Cabling
2. Copper Splices
3. Fiber Optic Backbone Cabling
4. Fiber Splices
5. Fiber Connectors
6. Coaxial Backbone Cabling

1.03 QUALITY ASSURANCE

A. All backbone cable installation, splicing, and termination shall be performed in a neat and Skillful manner. All methods of construction that are not specifically described or indicated shall be subject to the control of RTD.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval of RTD based on submittals provided.

C. Installations, materials, equipment and work quality shall conform to the specifications and drawings and all applicable provisions of the most recent versions of the following regulations, codes, and standards including all applicable addenda:

1. ANSI/NFPA 70 – National Electrical Code including, but not limited to, the following articles:
 - a. 250 – Grounding and Bonding
 - b. 300 – Wiring Methods
 - c. 645 – Information Technology Equipment
 - d. 725 – Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power-Limited Circuits
 - e. 770 – Optical Fiber Cables and Raceways
 - f. 800 – Communications Circuits
1. IEEE/NESC – National Electrical Safety Code

2. ANSI/TIA-568-C.0 – Generic Telecommunications Cabling for Customer Premises
3. ANSI/TIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA-568-C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standard
5. ANSI/TIA-568-C.3 – Optical Fiber Cabling Components Standard
6. ANSI/TIA-568-C.4 – Broadband Coaxial Cabling and Components Standard
7. ANSI/TIA-598-D – Optical Fiber Cable Color Coding
8. ANSI/TIA-604 Series – Fiber Optic Connector Intermate ability Standards
9. ANSI/TIA-606-B – Administration Standard for Commercial Telecommunications Infrastructure
10. ANSI/TIA-607-B – Generic Telecommunications Bonding and Grounding for Customer Premises
11. ANSI/TIA-758-B – Customer Owned Outside Plant Telecommunications Cabling Standard
12. ANSI/TIA-942-A – Telecommunications Infrastructure Standard for Data Centers
13. ANSI/ICEA S-83-596 – Indoor Optical Fiber Cables
14. ANSI/ICEA S-87-640 – Fiber Optic Outside Plant Communications Cable
15. BICSI Telecommunications Distribution Methods Manual
16. BICSI Telecommunications Cabling Installation Manual
17. BICSI Customer-Owned Outside Plant Manual

PART 2 – MATERIALS

2.01 INSIDE COPPER BACKBONE CABLING

- A.** Riser-Rated Non-Plenum (CMR) Category 3 UTP, 24 AWG
 1. 25-Pair
 2. 50-Pair
 3. 100-Pair
- B.** Plenum-Rated(CMP) Category 3 UTP, 24 AWG
 1. 25-Pair
 2. 50-Pair
 3. 100-Pair

2.02 OUTSIDE PLANT (OSP) COPPER TWISTED-PAIR BACKBONE CABLING

- A.** ASP Filled Core for Buried Installations, 24 AWG
 1. 25-Pair
 2. 50-Pair
 3. 100-Pair
 4. 200-Pair
 5. 300-Pair
 6. 400-Pair
 7. 600-Pair
 8. 900-Pair
 9. 1800-Pair

2.03 COPPER SPLICES

- A.** Splice Closure System for use in maintenance holes and tunnels: 2-Type System
 1. 2-Type Cover
 2. 2-Type Endplate
 3. Washer Cutter Tool Kit
- B.** Splice Closure System for inside ER and TR's: Split Sleeve Vault & Riser
 1. Split Sleeve for 200 Pair

- 2. Split Sleeve for 600 Pair
- C. Provide all required hardware and kits for field splicing in splice closures and for sealing and mounting the closures.
- D. 710 Splice Module – 25 pair splice connectors straight/filled with solid cap

2.04 INSIDE FIBER OPTIC BACKBONE CABLING

- A. Singlemode 8.3/125 Fiber Optic Cable
 - 1. 12-Strand Riser-Rated (OFNR)
 - 2. 12-Strand Plenum-Rated (OFNP)
 - 3. 24-Strand Riser-Rated (OFNR)
 - 4. 24-Strand Plenum-Rated (OFNP)
 - 5. 48-Strand Riser-Rated (OFNR)
 - 6. 48-Strand Plenum-Rated (OFNP)
- B. Multimode 62.5/125 Fiber Optic Cable – For Fire Alarm circuits and Existing Terminals Only – Coordinated with RTD IT
 - 1. 12-Strand Riser-Rated (OFNR)
 - 2. 12-Strand Plenum-Rated (OFNP)
- C. Multimode 50/125 OM4 Fiber Optic Cable
 - 1. 12-Strand Riser-Rated (OFNR)
 - 2. 12-Strand Plenum-Rated (OFNP)
 - 3. 24-Strand Riser-Rated (OFNR)
 - 4. 24-Strand Plenum-Rated (OFNP)

2.05 OUTSIDE PLANT FIBER OPTIC CABLE

- A. Singlemode 8.3/125 Tera Speed Outside Plant Fiber Optic Cable
 - 1. 6-Strand Dielectric
 - 2. 12-Strand Dielectric
 - 3. 24-Strand Dielectric
 - 4. 48-Strand Dielectric
 - 5. 96-Strand Dielectric
 - 6. 144-Strand Dielectric
- B. Multimode 62.5/125 Opti Speed Outside Plant Fiber Optic Cable – With RTD IT approval only
 - 1. 6-Strand Dielectric
 - 2. 12- Strand Dielectric
 - 3. 24-Strand Dielectric
- C. Multimode 50/125 OM4 Outside Plant Fiber Optic Cable – With RTD IT approval only
 - 1. 6-Strand Dielectric
 - 2. 12- Strand Dielectric
 - 3. 24- Strand Dielectric
 - 4. 48- Strand Dielectric
 - 5. 96- Strand Dielectric
 - 6. 144-Strand Dielectric

2.06 BACKBONE FIBER SPLICES

- A. Fiber Splice Closure:
 - 1. Fully equipped with cable addition kit
 - 2. Fiber Optic Splice Tray and all required accessories for a complete installation
- B. Provide all required hardware and kits for field fusion splicing in splice closures and for sealing and mounting the closures
- C. Field Splices other than hot Fusion or epoxy/polish are not acceptable.

2.07 FIBER CONNECTORS AND KITS

- A. LC Connector 0.9 mm for multimode 62.5/125 and 50/125 (OM4) fiber
- B. LC Connector 0.9 mm for singlemode fiber
- C. SC Connector 0.9 mm for multimode 62.5/125 fiber (for Fire Alarm and approved projects only)
- D. SC Connector 0.9 mm for multimode 62.5/125 and 50/125 (OM4) fiber (as approved to match existing only)
- E. Pigtails with LC Connectors for multimode 62.5/125 fiber
- F. Pigtails with LC Connectors for multimode 50/125 (OM4) fiber Pigtails with LC Connectors for singlemode fiber
- H. Pigtails with LC-APC Connectors for singlemode fiber (for CATV)
- I. Pigtails with SC-APC Connectors for singlemode fiber (for DAS only)
- J. Pigtails with SC Connectors for multimode 50/125 (OM4) fiber (as approved to match existing only)
- K. Breakout Kits for Outside Plant Cable
- L. Other consumables and kits as required for field termination of fiber optic cable on connectors
- M. Recloseable fiber storage rings: 12" diameter for inside plant, 24" diameter for outside plant
- N. Field Splices and terminations other than hot Fusion or epoxy/polish are not acceptable.

2.08 INSIDE COAXIAL BACKBONE CABLING

- A. Riser-Rated Non-Plenum (CATVR) .500 jacketed non-flooded cable.
- B. Plenum-Rated (CATVP) .500 jacketed non-flooded cable.

2.09 COAXIAL CONNECTORS

- A. All backbone splices, connectors, and adapters shall be specifically made for the use of the cable being used.

2.10 BACKBONE CABLE INSTALLATION MATERIALS, EQUIPMENT, AND TOOLS

- A. Furnish all required materials, equipment, and tools necessary to properly complete the backbone cabling system installation including, but not limited to: tools for pulling, splicing, and terminating the cables, mounting hardware, cable ties, bolts, anchors, clamps, hangers, kits of consumables, lubricants, communication devices, stands for cable reels, cable wenchers, etc.
- B. Mule-tape: Polyester or aramid fiber.
- C. Conduit Caulking Compound: Compounds for sealing conduit ducts shall have putty-like consistency workable with the hands at temperatures as low as 35 degrees Fahrenheit, shall not slump at a temperature of 300 degrees Fahrenheit, and shall not harden materially when exposed to the air. Compounds shall readily caulk or adhere to clean surfaces of plastic conduit, metallic conduits, or conduit coatings; concrete, masonry; any cable sheaths, jackets, covers, or insulation material, and the common metals. Compounds shall form a seal without dissolving, noticeable changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect on the hands of workers or upon materials.
- D. Cable Ties
 1. Heavy duty nylon cable ties for cable support inside and to Unistrut racking within tunnels and crawlspaces
 2. Nylon coated stainless steel ties to support splice cases to Unistrut racking and maintenance hole steps
- E. Fiber cable marker tags
- F. "Caution Fiber" labels

PART 3 - EXECUTION

3.01 BACKBONE CABLING INSTALLATION

- A. Perform all backbone cable installation in conformance with manufacturer's installation guidelines.
- B. Ensure that maximum pulling tensions of specified cables are not exceeded, and cable bends maintain the proper radius during placement.

- C.** Failure to follow appropriate guidelines for cable installation will require the Contractor to provide, in a timely fashion, the additional material and labor necessary to rectify the situation. This shall apply to any and all damages sustained to the cables during installation.
- D.** Field verify all cable measurements and install all backbone cables in such a manner as to avoid any and all mid-span splices. No mid-span splices are allowed except as specified and shown on project drawings.
- E.** Pull new Mule-tape through all conduit while pulling new backbone cable.
- F.** The Contractor shall be responsible for all damage to the cable during placement.
- G.** All new cables shall be supported using ladder cable runway, D-rings, and cable management hardware and shall be neatly dressed-out in the TRs, ERs, and Comm Huts.
- H.** Clamp all new cables at the entrance to the TRs, ERs, and Comm Huts for strain relief.
- I.** Do not roll or store cable reels without an appropriate underlay.
- J.** Clamp all new backbone cables at the entrance facilities for strain relief.
- K.** Backbone telecommunications cabling shall be placed in dedicated pathways separate from horizontal and other cabling.
- L.** For copper UTP or coaxial cable in J-hooks, cable tray, or non-metal pathways, maintain the following clearances from EMI sources:
1. Unshielded power lines or equipment less than 5 kVA: 12"
 2. Unshielded power lines or equipment equal to or greater than 5 kVA: 24"
 3. Power lines enclosed in grounded metal conduit less than 5 kVA: 6"
 4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 12"
Fluorescent fixtures: 12"
 5. Motors or transformers: 48"
- M.** For copper UTP or coaxial cable in grounded metal pathways (conduit), maintain the following clearances from EMI sources:
1. Unshielded power lines or equipment less than 5 kVA: 6"
 2. Unshielded power lines or equipment equal to or greater than 5 kVA: 12"
 3. Power lines enclosed in grounded metal conduit less than 5 kVA: 3"
 4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 6"
 5. Fluorescent fixtures: 6"
 6. Motors or transformers: 36"
- N.** Backbone cables installed inside buildings, crawlspaces and tunnels shall be strapped to supports or cable racks using heavy duty plastic cable ties.
- O.** Backbone cables in maintenance holes, and all splice cases installed in tunnels, crawl spaces and maintenance holes shall be strapped to the cable racks or maintenance hole steps using stainless steel ties.
- P.** Terminate cables so as not to pull tight on terminating equipment.
- Q.** Ensure that all splice closures are properly sealed for protection of the cable and splices.
- R.** Neatly and permanently label all backbone cables with the cable number at both ends and at all splice locations.
- S.** Firestop the insides of all sleeves through fire rated barriers after cable installation is complete.
- T.** Plug ends of conduit entering buildings with watertight conduit caulking compound after cable installation is complete to ensure foreign matter does not enter the buildings.
- U.** Test, label, and document the final backbone cable installation, including cable footages, on the as-built drawings.

3.02 COPPER UTP BACKBONE CABLE

- A.** Install copper UTP backbone cabling through conduit, tunnel, and crawl spaces, maintenance holes and other pathways as shown on the drawings.
- B.** Terminate cable on a Universal Consolidation Blocks and Patch Panels in each ERs, TRs, and Comm Huts as shown on the project drawings and following the industry standard color code sequence.

3.03 FIBER BACKBONE CABLE

- A. Install fiber optic backbone cable through conduit, tunnel, crawl spaces, maintenance holes and other pathways as shown on the drawings.
- B. Install fiber storage rings on plywood backboard in TRs, ERs, and Comm Huts as required for project and shown on drawings.
- C. Install fiber cable service coils, with length of at least 20 feet, on fiber storage rings, at each end of all new backbone fiber optic cables, to control excess cable lengths, before terminating fiber strands. Each fiber coil shall be Velcro individually for ease of maintenance and repair work. Do not leave fiber cable slack on walls or ladder racks.
- D. Do not install fiber storage rings and coils on cable or equipment racks. D-rings shall not be used to support the fiber storage rings or coils.
- E. Place "Caution Fiber" tags at all coils and every 50' along the cable route.
- F. TRs, ERs, and Comm Huts without fiber coils shall be marked "No fiber coil" on the drawings.
- G. Fiber schematics for termination of backbone fiber strands in the fiber enclosures will be provided by RTD IT.
- H. Terminate fiber strands on connectors or pigtails in fiber enclosures and panels in the TRs, ERs, and Comm Huts, as shown on the project drawings, schematics, and per manufacturer's specifications and color sequence. Splice kits or wallets shall be used within the fiber enclosures to support pigtail splices within fiber enclosures, per manufacturer's specifications.
- I. Perform termination of multimode fiber strands on SC and LC connectors with loss \leq 0.5 dB at 850 nm.
- J. Perform termination of singlemode fiber strands on SC and LC connectors with loss \leq 0.2 dB at 1310 nm
- K. Do not terminate, splice or cut off "DEAD" cable strands. Neatly coil these unterminated strands inside the fiber enclosure with the proper bend radius to protect them for future termination or splicing.
- L. Perform fusion splices for multimode and singlemode fiber strands at each splice location with strand numbering as indicated on the drawings.
- M. Perform fusion splices for singlemode fiber strands and pigtails with splice loss \leq 0.2 dB at 1310 nm.
- N. Perform fusion splices for multimode fiber strands and pigtails with splice loss \leq 0.3 dB at 850 nm.
- O. All Fiber installations and runs must follow NECA/FOA 301 Standards
- P. Any Fiber runs Outside Plant (OSP) will be run with Purple tracer wire in trench or in Poly Conduit.
 1. TRACER WIRE – RTD uses Purple Coated Insulation to differentiate from other Tracers run in the same locations and Conduit.
 2. Purple Tracer wire must be provided and placed in communication conduits containing fiber optic cable as shown on the plans. Purple Tracer wire must be No. 16 minimum solid copper conductor with Type TW, THW, RHW, or USE insulation. A minimum of 3 ft of slack must be extended into each communication pull box, splice vault and fiber optic vault from each direction. The purple tracer wire must form a mechanically and electrically continuous line throughout the length of the trench. Where trenched communication conduit joins metal conduit that has been jacked or drilled, the Purple tracer wire must be bonded to the metal conduit with a brass grounding clamp. Purple Tracer wire may be spliced at intervals of not less than 500 feet and in pull boxes. Splices must conform to Section 86-2.09, "Wiring," of the Standard Specifications.

3.04 SAFETY

- A. Comply with RTD regulations as specified in RTD Safety standards for all backbone cable installation work, including, but not limited to, work in confined spaces, and mitigation of asbestos, lead, or other hazardous materials.
- B. Guard maintenance hole and tunnel openings per NESC requirements:
 1. When covers of maintenance holes, handholes, or vaults are removed, the opening shall be promptly protected with a barrier, temporary cover, or other suitable guard.
- C. Test for gas in maintenance holes and unventilated vaults per NESC requirements.

3.05 AS-BUILT DRAWINGS

- A. Mark the project drawings with notations reflecting actual cable lengths and any variations from the base specifications and drawings including as-built cable routing.
- B. Comply with "Construction Drawings AS-BUILT Requirements"

SECTION 27 13 23

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1- GENERAL

1.01 SCOPE OF WORK

- A. This specification includes Buffered Optical Fiber Cables for Indoor/outdoor Distribution Applications.
- B. Optical fiber cabling for Backbone applications.
- C. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified by RTD IT, and in performing the following operations recognized as necessary for the installation, termination, and labeling of the backbone optical fiber infrastructure as described on the drawings and/or required by these specifications.
 1. Installation, splicing, termination, testing, labeling and documentation of new fiber optic communication cable between buildings, com houses, and com cases as specified and on the drawings.
 2. The installation environment could include tie in and coordination with existing and new optical fiber and copper facilities, direct-buried conduit, and railway pathways.
 3. The Contractor shall be responsible for: placement of cable, installation and attachment of cable to support devices within the system, the placement of conduit, the installation of pull-boxes, hand holes, the furnishings of fiber optic splice closures, and installation of termination hardware, and other as specified by RTD IT.
 4. Contractor shall be responsible for providing and installing grounding and bonding materials, and fire stopping materials as required completing the installation.
 5. Other incidental hardware and appliances, necessary for the proper performance and operation of the communication cable system, which are consistent with the practices of cable installation, are to be provided by the Contractor as required to complete the installation.
 6. Contractor is responsible to ensure that utility locating has been performed as per the requirements of RTD cable Location Specifications. The Contractor is responsible for any damages to any utility caused during construction.
 7. Contractor is responsible to provide RTD IT, upon completion of the project an itemized spreadsheet of all Fiber, Products, and materials for RTD IT Asset management.

1.02 RELATED SECTIONS

- A. Section - 27 05 29
- B. Section - 27 11 00
- C. Section - 27 13 00
- D. Section - 27 15 00
- E. Section - 27 15 23
- F. Section - 27 16 00

1.03 REFERENCES

- A. The Contractor is held responsible to be knowledgeable with the provisions contained herein and with other Sections of this Specification as applicable to the completion of the installation. The Contractor is held responsible is assumed to possess the working knowledge, manpower, and materials applicable to the completion of the installation as specified in all specifications within the RTD IT Division 27 standards specifications.
 1. ANSI/TIA-526-14-C - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant, Fiber-Optic Communications Subsystem Test Procedures.

2. ANSI/TIA 568.3-D - Optical Fiber Cabling Components
3. FOTP-3 - Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components
4. FOTP-25 - Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies
5. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test
6. FOTP-37 - Fiber Optic Cable Bend Test, Low and High Temperature
7. FOTP-38 - Measurement of Fiber Strain in Cables Under Tensile Load
8. FOTP-85 - Fiber Optic Cable Twist Test
9. FOTP 104 - Fiber Optic Cable Cyclic Flexing Test
10. EIA/TIA-598 - Optical Fiber Cable Color Coding.
11. ICEA S-83-596 - Standard for Fiber Optic Premises Distribution Cable
12. NFPA 70 - National Electric Code (NEC)
13. ANSI/UL 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
14. ISO 11801 - Generic Cabling for Customer Premises

1.04 DESIGN / PERFORMANCE REQUIREMENTS

- A. Structured cabling system shall be able to support interconnections to active telecommunications equipment for voice and data applications in a multi-vendor, multi product environment. Structured cabling system should adhere to ANSI/TIA 568 B; 569-A; 606-A; J-STD-607-A and TIA 942 standards with respect to pathways, distribution, administration, and grounding of the system. Structured cabling system be installed in accordance to local codes and regulations.
- B. Floor serving active data equipment will be interconnected to the facility serving data equipment via a fiber backbone terminated in rack mounted enclosures which will utilize SC or LC connections. This will serve to connect the Main Telecommunications Room to an additional Telecommunications Room serving the locations that exceed the distance limitations (90 meters) of the Main Telecommunications Room for the horizontal Data and Voice drops.
- C. Metallic hardware used in fiber optic cabling systems (such as wall-mounted termination boxes, racks, and patch panels) must be grounded in accordance with ANSI/TIA/EIA 607, NECA-BICSI-568.

1.05 SUBMITTALS

- A. Product Data: Manufacturer's data sheets on each product to be used, including:
 1. Storage and handling requirements and recommendations.
 2. Installation procedures and technical support concerning the items contained in this specification.
- B. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be ISO9001, TL9000 and/or ISO14001 registered, for quality assurance.
- B. Regulatory Requirements: Conform to all applicable codes and ordinances for flame, fuel, smoke and volatile organic compounds (VOC) ratings requirements for finishes at time of application.
- C. Fiber Optical Cable: All optical fibers in cables lengths of 300 m or greater shall be 100% attenuation tested. Attenuation shall be measured at 850 nm and 1300 nm for Multimode and 1310 nm and 1550 nm for Single-mode. Manufacturer shall store a record of these values for a minimum of 5 years and the recorded values shall be available upon request.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handle and store products in accordance with the manufacturer's requirements. Store in manufacturer's unopened packaging with all labels intact until ready for installation.
- B. Package completed cable for shipment on non-returnable wooden reels. Required cable lengths shall be stated in the purchase order.
 - 1. Top and bottom ends of the cable shall be available for testing.
 - 2. Both ends of the cable shall be sealed to prevent the ingress of moisture.
 - 3. Each reel shall have a weather resistant reel tag attached identifying the reel and cable.
- C. Package cable in cartons and/or wound on spools. Each package shall contain only one continuous length of cable. Construct packaging to prevent damage to the cable during shipping and handling.
- D. Securely fasten the outer end of the cable to the reel head to prevent the cable from becoming loose in transit. Inner end of the cable shall project into a slot in the side of the reel or into a housing on the inner slot of the drum, in a manner and of sufficient length to make it available for testing.
- E. Test tails shall be at least two meters long. Fasten the inner end to prevent the cable from becoming loose during shipping and installation.

Reel Marking and Labeling. Every cable reel be marked as follows:

- 1. Reel Label:
 - a. Part number
 - b. Reel number
 - c. Length (ft/m)
 - d. Marking (ft/m) top and bottom
 - e. Date of manufacture
 - f. Listing information
- 2. Bar Code Label:
 - a. Package ID
 - b. Reel number
 - c. Quantity
 - d. Customer ID
 - e. Package count
 - f. Factory order number
 - g. Release part number
 - h. Length (ft)
 - i. "Ship to:" address"
- 3. Stenciling:
 - a. Manufacturer's name and address
 - b. Direction of rotation
 - c. Reel size
 - d. "DO NOT LAY REEL ON SIDE"

1.08 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturer: Corning Optical Communications LLC, which is located at: 800 17th St. NW; Hickory, NC 28601; Toll Free Tel: 800-743-2675; Tel: 828-901-5000.
Email: [request info \(eliteadvan@corning.com\)](mailto:requestinfo(eliteadvan@corning.com));
Web: <http://www.corning.com/worldwide/en/products/communication-networks/products.html>
- B. Requests for substitutions will be considered, substitution requests shall include all required product data and shall be complete with reasons for substitutions and savings, which will accrue to RTD if substitutes are approved. Substitutes will be considered only if equal or superior to that specified.
- C. All Fiber, Products, and materials turned over to RTD in the project provided will be itemized and entered in a spreadsheet to be turned over to RTD IT Asset management.

2.02 BUFFERED OPTICAL FIBER CABLES FOR INDOOR DISTRIBUTION

- A. General:
 - 1. Cable shall meet the requirements of the National Electrical Code (NEC) Section 770:
 - a. Non-Plenum Applications: Applicable Flame Tests: ANSI/UL 1666. Cables shall be listed OFNR.
 - b. Finished cables shall be tested to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Fiber Optic Premises Distribution Cable (ICEA S-83-596).
 - 2. Cable shall be all-dielectric.
- B. Fiber Specifications:
 - 1. Detailed information on the cabled performance of the fiber types available for this cable design shall be found in the following manufacturers specifications:
 - a. Dispersion Un-shifted Single-mode Fiber: Corning Generic Specification F3, "Generic Specification for Single-mode Optical Fiber in Tight Buffer Cables."
 - b. 50/125 µm and 62.5/125 µm Multimode Fiber: Corning Generic Specification F4, "Generic Specification for Multimode Optical Fiber in Tight Buffer Cables."
- C. Cable Construction:
 - 1. All fibers, except white, shall be colored with ultraviolet (UV) curable inks. Fibers occupying the white position shall be left uncolored.
 - 2. All fibers shall be coated with a low friction slip layer.
 - 3. Coated fibers shall be buffered with a thermoplastic compound to a diameter of 900 ± 50 SYMBOL 109 "Symbol" 10m.
 - 4. Individual fiber's 900 µm buffer coating shall be color coded for identification. Color coding shall be in accordance with EIA/TIA-598, "Optical Fiber Cable Color Coding." Coloring material shall not be susceptible to migration and shall not affect the transmission characteristics of the optical fibers. Color-coded buffered fibers shall not adhere to one another. Buffered mechanical fibers in filler subunits, where used, shall be white (natural).
 - 5. When buffered fibers are grouped into individual subunits, each subunit jacket shall be numbered for identification, with the exception of filler subunits where used. Numbers shall be repeated at regular intervals.
 - 6. Fiber coating and buffer shall be removable with commercially available stripping tools in a single pass for connectorization or splicing.
- D. Cable Core Construction: Strength members shall consist of high modulus strength yarns. Strength yarns shall be helically stranded around the buffered fibers. Non-toxic, non-irritant talc shall be applied to the yarns to allow them to be easily separated from the fibers and the jacket.
 - 1. Non-unitized Cables, 2 to 24 Fibers: Fiber shall be stranded around a dielectric strength element and surrounded by layered strength yarns. Strength element shall be overcoated with a thermoplastic, when

required, to achieve dimensional sizing to accommodate and support the 900 μm buffered fibers. Cables having 12 to 24 fibers shall be dual layered. Strength yarns shall serve as the tensile strength members of the cable. A ripcord may be applied between the strength yarns and the outer jacket to facilitate jacket removal. An outer jacket shall be extruded over the strength yarns for physical and environmental protection.

2. Unitized Cables, 24 to 72 Fibers: Buffered fibers shall be grouped in six fiber subunits. In each subunit, individual fibers shall be stranded around a dielectric strength element and surrounded by layered strength yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. Subunit jacket shall be extruded over the strength yarns for additional physical and environmental protection. Subunits shall be stranded around a dielectric central member. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. An outer jacket shall be extruded around the subunits.
3. Unitized Cables, 72 to 144 Fibers: Buffered fibers shall be grouped in twelve fiber subunits. In each subunit, the individual fibers shall be stranded around a dielectric strength element and surrounded by layered strength yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. Subunit jacket shall be extruded over the strength yarns for additional physical and environmental protection. Subunits may be stranded around a dielectric central member. Cables may contain filler subunits to provide symmetry to the cable design. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. An outer jacket shall be extruded around the subunits.

E. Cable Jacket:

1. Jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. Jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. Jacket shall be smooth, as is consistent with the best commercial practice. Jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
2. Nominal thickness of the cable outer jacket shall be sufficient to provide adequate cable protection while meeting the mechanical, flammability, and environmental test requirements of this document over the life of the cable.
3. Cable jacket and subunit jacket color shall be orange for cables/subunits containing multimode fiber except for cables/subunits containing 50/125 μm Laser Optimized Fiber, which shall have an aqua colored jacket. Cable/subunit jacket color shall be yellow for cables containing single-mode fiber.
4. Outer cable jacket shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet (e.g., "CORNING OPTICAL CABLE - MM/YY - 12 SME - EOS - OFNR FT4 c(ETL)us 00001 FEET"). Marking shall be in contrasting color to the cable jacket.

F. Cable Performance:

1. Temperature Range:
 - a. Storage temperature range for cable on the original shipping reel shall be -40 degrees C to +70 degrees C.
 - b. Installation temperature range for riser cables shall be -10 degrees C to +60 degrees C.
 - c. Operational temperature range for riser cables shall be -20 degrees C to +70 degrees C. Testing shall be in accordance with FOTP-3.

G. Crush Resistance:

1. When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," cable shall withstand a minimum compressive load of 100 N/cm (57 lbf/in) applied uniformly over the length of the compression plate.
2. While under compressive load, the fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).

H. Cyclic Flexing:

1. When tested in accordance with FOTP 104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute.
2. Fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).
3. Jacket shall not crack, split, or tear.

I. High and Low Temperature Bend:

1. When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," cable shall withstand four full turns around a mandrel at an installation temperatures of -10 degrees C and +60 degrees C. Mandrel diameter shall be the greater of 20 times the cable OD or 150 mm.
2. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).

J. Impact Resistance:

1. When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," cable shall withstand a minimum of 2 impact cycles at 3 locations spaced a minimum distance of 150 mm. Impact energy shall be 2.94 Nm.
2. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).
3. Jacket shall not crack, split or tear.

K. Temperature Cycling:

1. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after the second cycle at extreme operational temperatures (-20 degrees C and +70 degrees C) shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). Change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling.

L. Twist-Bend:

1. When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting and bending.
2. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or 0.60 dB at 1300 nm (multimode).

M. Tensile and Fiber Strain:

1. When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, "Measurement of Fiber Strain in Cables Under Tensile Load," a length of cable shall be tested to the rated tensile load.
2. For cables < 12f the rated tensile load is 660 N (148 lbf) and for cables > 12f the rated tensile load is 1320 N (297 lbf).
3. While under rated tensile load, fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load), the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).
4. After the tensile load is removed, fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until support structures and substrates have been properly prepared.
- B. Verify installation of support structures for backbone fiber optic cables before the installation.
- C. Do not install a fiber optic cable in a conduit or duct that already contains cabling, regardless of the cable type unless approved by RTD IT.
- D. Remove all abandoned cables unless unused cables are reserved for future use or cable that is not terminated at equipment other than a connector and not identified for future use with a tag as required by the National Electrical Code.
- E. If support structures and substrate preparation are the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 INSTALLATION

- A. General: Cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification.
- B. Testing and Acceptance:
 1. All cables shall be tested according to the requirements of ANSI/TIA 568.3-D. Any defects in the cabling, connectors, couplers or patch panels shall be repaired or replaced in order to ensure 100% useable fiber in all cables installed.
 2. For horizontal cabling system using multimode optical fiber, attenuation shall be measured in one direction at either 850 nanometer (nm) or 1300 nm using an LED light source and power meter with an encircled flux (EF) compliant reference jumper per ANSI/TIA-526-14-C.
 3. If performing Tier II testing with an OTDR, fiber cabling shall be tested at both 850 nm and 1300 nm for Multimode or 1310 nm and 1550 nm for single mode. This should be a bi-directional test that averages the values to compensate for any mode field mismatch.

3.03 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

3.04 SCHEDULES

Select the applicable Paragraphs below as required to suit project requirements. Identify products by name on the Drawings or use this paragraph to define the location of each type of material to be used.

- A. Indoor Fiber Optic Cable
 1. Ribbon
 - a. Ribbon, Riser; Corning Generic Spec PGS043
 - b. Ribbon, Interlocking Armored, Riser; Corning Generic Spec PGS043
 - c. UltraRibbon Indoor, Gel-Free, Riser; Corning Generic Spec PGS043
 - d. UltraRibbon Indoor, Gel-Free, Interlocking Armored, Riser; Corning Generic Spec PGS043

- e. LSZH Ribbon; Corning Generic Spec PGS056
 - f. LSZH UltraRibbon Indoor Gel-Filled; Corning Generic Spec PGS056
 - g. LSZH UltraRibbon Indoor Gel-Free; Corning Generic Spec PGS056
2. Tight-Buffered
- a. Fan-out Tight Buffered, Riser; Corning Generic Spec PGS017
 - b. Fan-out Tight Buffered, Interlocking Armored, Riser; Corning Generic Spec PGS017
 - c. MIC Tight Buffered, Riser; Corning Generic Spec PGS049
 - d. MIC Tight Buffered, Interlocking Armored, Riser; Corning Generic Spec PGS049
 - e. MIC Unitized Tight Buffered, Riser; Corning Generic Spec PGS049
 - f. MIC Unitized Tight Buffered, Interlocking Armored, Riser; Corning Generic Spec PGS049
 - g. Reel In A Box, MIC Tight Buffered, Riser; Corning Generic Spec PGS049

B. Indoor/Outdoor Fiber Optic Cable

1. Loose Tube
- a. LSZH Loose Tube, Gel-Free, Single-Jacket; Corning Generic Spec PGS015
 - b. LSZH Loose Tube, Gel-Free, Double-Jacket; Corning Generic Spec PGS015
 - c. LSZH Loose Tube, Gel-Free, Corrugated Armored; Corning Generic Spec PGS015
 - d. LSZH Loose Tube, Gel-Free, Interlocking Armored; Corning Generic Spec PGS015
 - e. FREEDM LST Loose Tube, Gel-Free, Riser; Corning Generic Spec PGS070
 - f. FREEDM LST Loose Tube, Gel-Free, Interlocking Armored, Riser; Corning Generic Spec PGS070
 - g. LSZH Loose Tube, Indoor/Outdoor, Gel-Free, Double Jacket, Rodent Resistant; Corning Generic Spec PGS071
 - h. FREEDM Loose Tube, Gel-Free, Riser; Corning Generic Spec PGS073
 - i. FREEDM Loose Tube, Gel-Free, Interlocking Armored, Riser; Corning Generic Spec PGS073
 - j. Industrial LSZH Tray-Rated, Loose Tube, Gel-Free; Corning Generic Spec PGS101
 - k. Industrial LSZH Tray-Rated, Loose Tube, Gel-Free, Double Jacket; Corning Generic Spec PGS101
 - l. Industrial LSZH Tray-Rated, Loose Tube, Gel-Free, Corrugated Armored; Corning Generic Spec PGS101
 - m. Industrial LSZH Tray-Rated, Loose Tube, Gel-Free, Interlocking Armored; Corning Generic Spec PGS101
 - n. Industrial LSZH Tray-Rated, Loose Tube, Gel-Free, Double Jacket, Rodent Resistant; Corning Generic Spec PGS101
 - o. Mining and Petrochemical Tray-Rated, Loose Tube, Gel-Free; Corning Generic Spec PGS116
2. Ribbon
- a. FREEDM UltraRibbon, Gel-Filled, Riser; Corning Generic Spec PSG5026
 - b. FREEDM UltraRibbon, Interlocking Armored, Gel-Filled, Riser; Corning Generic Spec PGS026
 - c. LSZH UltraRibbon, Gel-Filled; Corning Generic Spec PGS056
 - d. LSZH UltraRibbon, Gel-Free; Corning Generic Spec PGS056
 - e. LSZH UltraRibbon Indoor/Outdoor Interlocking Armored, Gel-Filled; Corning Generic Spec PGS056
 - f. LSZH Ribbon Gel-Filled; Corning Generic Spec PGS056
 - g. LSZH Ribbon, Interlocking Armored Gel-Filled; Corning Generic Spec PGS056
 - h. FREEDM Ribbon, Gel-Filled, Riser; Corning Generic Spec PGS057
 - i. FREEDM Ribbon, Interlocking Armored, Gel-Filled, Riser; Corning Generic Spec PGS057
 - j. FREEDM UltraRibbon, Gel-Free, Riser; Corning Generic Spec PGS070
 - k. FREEDM UltraRibbon, Interlocking Armored, Gel-Free, Riser; Corning Generic Spec PGS070
 - l. Indoor/Outdoor Oil-Resistant Armored; Corning Generic Spec PGS071
 - m. Indoor/Outdoor Oil-Resistant Light Armored; Corning Generic Spec PGS071
3. Tight-Buffered
- a. FREEDM One Tight-Buffered, Riser; Corning Generic Spec PGS061
 - b. FREEDM One Tight-Buffered, Interlocking Armored, Riser; Corning Generic Spec PGS061

- c. FREEDM One Unitized, Tight-Buffered, Riser; Corning Generic Spec PGS061
 - d. FREEDM One Unitized, Tight-Buffered, Interlocking Armored, Riser; Corning Generic Spec PGS061
 - e. FREEDM Fan-Out Tight-Buffered, Riser; Corning Generic Spec PGS137
 - f. FREEDM Fan-Out Cold-Temperature, Tight-Buffered, Riser; Corning Generic Spec PGS137
 - g. Reel in a Box, FREEDM Fan-Out Tight-Buffered, Riser; Corning Generic Spec PGS137
4. Hybrid:
- a. ActiFi FREEDM DAS, Indoor/Outdoor, Riser; Corning Generic Spec PGS130
 - b. ActiFi FREEDM DAS, Indoor/Outdoor, Interlocking Armored, Riser; Corning Generic Spec PGS130

SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD IT Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section.

1.02 SCOPE OF WORK

A. Provide all services, labor, materials, tools, and equipment required for the complete and proper installation and termination of new horizontal “station” cabling as called for in these specifications and related drawings.

B. The horizontal portion of the telecommunications cabling system extends from the work area telecommunications outlet to the termination in the Telecommunications Room (TR) Communication Hut/Case (Comm Hut), or Equipment Room (ER).

C. This section includes minimum requirements and installation methods for the following:

1. Copper Horizontal Cabling
2. Fiber Optic Horizontal Cabling
3. Work Area Faceplates
4. Copper Modular Jacks
5. Fiber Modular Jacks and Connectors
6. Coaxial Horizontal Cabling

1.03 QUALITY ASSURANCE

A. All horizontal “station” cable installation and termination shall be performed in a neat and skillful manner. All methods of construction that are not specifically described or indicated shall be subject to the control of RTD.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval of RTD based on submittals provided.

C. Installations, materials, equipment and work quality and performance shall conform to the specifications and drawings and all applicable provisions of the most recent versions of the following regulations, codes, and standards including all applicable addenda:

1. ANSI/NFPA 70 – National Electrical Code including, but not limited to, the following articles:
 - a. 300 – Wiring Methods
 - b. 645 – Information Technology Equipment
 - c. 725 – Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power-Limited Circuits
 - d. 770 – Optical Fiber Cables and Raceways

- e. 800 – Communications Circuits
- 2. ANSI/TIA-568-C.0 – Generic Telecommunications Cabling for Customer Premises
- 3. ANSI/TIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- 4. ANSI/TIA-568-C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standard
- 5. ANSI/TIA-568-C.3 – Optical Fiber Cabling Components Standard
- 6. ANSI/TIA-568-C.4 – Broadband Coaxial Cabling and Components Standard
- 7. ANSI/TIA-604 Series – Fiber Optic Connector Intermateability Standard
- 8. ANSI/TIA-606-B – Administration Standard for Commercial Telecommunications Infrastructure
- 9. ANSI/ICEA S-83-596 – Indoor Optical Fiber Cables
- 10. BICSI Telecommunications Distribution Methods Manual
- 11. BICSI Telecommunications Cabling Installation Manual

PART 2 – MATERIALS

2.01 COPPER HORIZONTAL CABLING

- A.** Category 6, 4-Pair UTP Cabling
 - 1. Plenum Rated (CMP)
- B.** Category 6A, 4-Pair UTP Cabling – For special data installation by approval from RTD IT and all wireless circuits (two cables per wireless Access Point - AP)
 - 1. Plenum Rated (CMP)

2.02 FIBER OPTIC HORIZONTAL CABLING

- A.** Singlemode 8.3/125 Fiber Optic Cable
 - 1. 2-Strand Plenum-Rated (OFNP)
 - 2. 6-Strand Plenum-Rated (OFNP)
 - 3. 2-Strand Outside Plant (OSP)
 - 4. 6-Strand Outside Plant (OSP)
- B.** Multimode 62.5/125 Fiber Optic Cable – For Fire Alarm circuits and Existing Terminals Only – Coordinated with RTD IT
 - 1. 2-Strand Plenum-Rated (OFNP)
 - 2. 6-Strand Plenum-Rated (OFNP)
 - 3. 2-Strand Outside Plant (OSP)
 - 4. 6-Strand Outside Plant (OSP)
- C.** Multimode 50/125 OM4 Fiber Optic Cable
 - 1. 2-Strand Plenum-Rated (OFNP)
 - 2. 6-Strand Plenum-Rated (OFNP)
 - 3. 2-Strand Outside Plant (OSP)
 - 4. 6-Strand Outside Plant (OSP)

2.03 COPPER UTP MODULAR JACKS FOR OUTLETS AND PATCH PANELS

- A.** Category 3, 8-Position, 8-Conductor Jack – For replacement to Match Existing – Coordinated with RTD IT.
 - 1. T568B wiring
 - 2. Supports minimum of 750 plug insertions
 - 3. Designed to fit opening in modular faceplate
- B.** Category 5e, 8-Position, 8-Conductor Jack – For replacement to Match Existing – Coordinated with RTD IT.
 - 1. T568B wiring
 - 2. Supports minimum of 750 plug insertions
 - 3. Designed to fit opening in modular faceplate

- D. Category 6A, 8-Position, 8-Conductor Jack – For wireless AP and special installations as approved in advance by RTD IT.
 1. T568B wiring
 2. Designed to fit opening in modular faceplate

2.04 FIBER CONNECTORS AND ADAPTERS FOR OUTLETS

- A. LC Duplex Keystone Adapter for Singlemode Fiber
 1. Designed to fit opening in modular faceplate
- B. LC Duplex Keystone for Multimode 62.5/125 Fiber
 1. Designed to fit opening in modular faceplate
- C. SC Simplex Keystone Adapter for Multimode 62.5/125 Fiber
 1. Designed to fit opening in modular faceplate
- D. LC Duplex Keystone Adapter for Multimode 50/125 OM4 Fiber
 1. Designed to fit opening in modular faceplate
- E. LC-APC Duplex Keystone Adapter for Singlemode Fiber with Angled Polished Connector
 1. Designed to fit opening in modular faceplate
- F. LC Connector 0.9 mm for multimode 62.5/125 and 50/125 (OM4) fiber
- G. LC Connector 0.9 mm for singlemode fiber
- H. SC Connector 0.9 mm for multimode 62.5/125 fiber
- I. Pigtails with LC Connectors for multimode 62.5/125 fiber
- J. Pigtails with LC Connectors for multimode 50/125 (OM4) fiber
- K. Pigtails with LC Connectors for singlemode fiber
- L. Pigtails with LC-APC Connectors for singlemode fiber (for CCTV and DAS)
- M. Consumables and kits as required for field termination of fiber optic cable on connectors

2.05 INSTALLATION MATERIALS, EQUIPMENT, AND TOOLS

- A. Furnish all required materials, equipment, and tools necessary to properly complete the horizontal copper UTP, coaxial CCTV, and fiber optic cabling system installation including, but not limited to: tools for pulling and terminating the cables, mounting hardware, cable ties, bolts, anchors, clamps, hangers, kits of consumables, lubricants, communication devices, stands for cable reels, cable wenchers, etc.
- B. Poly line: poly pull line with a minimum pull tensile strength of 200 pounds.

PART 3 - EXECUTION

3.01 HORIZONTAL CABLING INSTALLATION

- A. Install faceplates with UTP copper, coax and fiber jacks at each work area outlet location as indicated on the project drawings. Place the jacks in the faceplates beginning with position A and placing the copper jacks before the fiber adapter jacks. Place blank covers in the unused openings on each faceplate.
- B. Faceplates shall be secured with mechanical fasteners. Adhesive fasteners shall not be allowed.
- C. Install copper UTP, fiber optic horizontal cable from each work area outlet location indicated on the drawings to the TR, or ER, designated on the project drawings.
- D. Where any portion of the horizontal cable will be routed outside, or under slab, OSP rated cable shall be installed. OSP horizontal cabling shall be fully enclosed in conduit for the entire route from the outlet to the ER or TR.
- E. All horizontal cabling terminating within a single faceplate must be routed to and terminated in the same ER or TR.
- F. Install one surface housing and two Category 6A jacks inside each Wireless AP Surface Enclosure and Wireless AP Right-Angle Wall Bracket.
- G. Install two Category 6A jacks above each Wireless AP Grid Ceiling Location
- H. Perform all horizontal cable installation in conformance with manufacturer's installation guidelines.

I. Ensure that maximum pulling tensions of specified cables are not exceeded, and cable bends maintain the proper radius during placement.

J. The horizontal cable distribution system design uses conduit, surface raceway, cable tray, and/or J-hooks for support from the outlet location to the TR or ER as specified and shown on the project drawings. Coordinate as necessary with electrical contractor for placement of horizontal cable pathways and outlet boxes.

K. Horizontal telecommunications cabling shall be placed in dedicated pathways separate from backbone and other cabling. The only exception is within cable trays that may have both horizontal and backbone telecommunications cabling separated as far as possible within the trays.

L. All horizontal cables within the ERs and TRs shall be bundled with Velcro cable every 8 to 12 inches from the patch panels to the point where the cables exit the room. The Velcro cable ties shall hold, but not deform, the cables, and shall overlap a minimum of 2" to allow for more cable to be added in the future. Cable bundles shall have no more than 32 cables per bundle.

M. A small drip loop is required on the horizontal cables at the patch panel for trouble shooting and future changes. The drip loop on the horizontal cable should be approximately 2RU from the jack in the panel to the bottom of the loop.

N. The horizontal cabling routing from each jack on the back of the patch panels shall route to the nearest side of the panel and shall not cross the center line of the panel. The only exception is for hinged swing-out wall racks, where the horizontal cabling will route from each jack to the hinged side of the panel to allow the rack to swing open for future installations and maintenance.

O. Install new Poly line in all conduits and cable trays while pulling in new horizontal cables.

P. Ceiling tile shall be removed as necessary for the cable installation and put back in place without damaging or dirtying any of the tiles or supporting framework. Ceiling tile shall be handled with clean hands so that no fingerprints or marks are left on the tiles. The contractor is responsible for the cost of repair or replacement of any damaged or dirtied tiles or ceiling hardware.

Q. All cables in the ceiling space:

1. shall be supported in conduit or in the cable tray and shall not droop or hang outside of cable tray.
2. shall not be run "wild" (unsupported by conduit, cable tray, or J-hooks) for distances greater than four feet.
3. shall not be attached to the suspended ceiling structure or laid directly on the ceiling grid as a means of support.
4. shall not be supported by or attached by any means to fire sprinkler heads or delivery systems, any environmental sensor, or the exterior of any conduit or raceway.
5. shall be routed at right angles to the electrical power circuits where the cable is not enclosed in conduit or in cable tray.

R. Where specifically allowed by RTD IT, J-hooks shall be specifically designed and installed for the purpose of supporting telecommunications cables. The J-hooks shall be attached to the building structure and framework at a maximum of four-foot intervals. Existing bridle rings may be left in place to support existing cables that are not removed. Bridle rings shall not be used to support new cables.

S. All cables in J-hooks shall be bundled with plenum rated Velcro cable ties every 8 to 12 inches. The Velcro cable ties shall hold, but not deform, the cables, and shall overlap a minimum of 2" to allow for more cable to be added in the future. Cable bundles shall have no more than 32 cables per bundle.

T. The total length of any horizontal station cable from the jack location at the outlet to the termination in the ER or TR shall not exceed 290 feet. Where building or infrastructure conditions prohibit meeting this requirement, notify the RTD IT Manager and Consultant immediately for resolution.

U. Manage slack for the entire horizontal cable run to avoid excess cable or kinking.

V. For copper UTP or coaxial cable in J-hooks, cable tray, or non-metal pathways, maintain the following clearances from EMI sources:

1. Unshielded power lines or equipment less than 5 kVA: 12"
2. Unshielded power lines or equipment equal to or greater than 5 kVA: 24"
3. Power lines enclosed in grounded metal conduit less than 5 kVA: 6"
4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 12"
5. Fluorescent fixtures: 12"
6. Motors or transformers: 48"

W. For copper UTP or coaxial cable in grounded metal pathways (conduit), maintain the following clearances from EMI sources:

1. Unshielded power lines or equipment less than 5 kVA: 6"
2. Unshielded power lines or equipment equal to or greater than 5 kVA: 12"
3. Power lines enclosed in grounded metal conduit less than 5 kVA: 3"
4. Power lines enclosed in grounded metal conduit equal to or greater than 5 kVA: 6"
5. Fluorescent fixtures: 6"
6. Motors or transformers: 36"

X. Do not splice or bridge tap the horizontal cable.

Y. All cables shall be tied and dressed neatly with a minimum bend radius of 10 times the cable diameter. Provide necessary hardware to maintain proper bend radius at corners.

Z. All cables shall be firmly held in place. Fastenings and supports shall be adequate to support loads with ample safety factors.

AA. Failure to follow appropriate guidelines for cable installation will require the Contractor to provide, in a timely fashion, the additional material and labor necessary to rectify the situation. This shall apply to any and all damages sustained to the cables during installation.

BB. The Contractor shall be responsible for all damage to the cable during placement.

CC. Cables with jackets that are chaffed or burned exposing internal conductor insulation or have any bare copper (shiners) shall be replaced.

DD. Do not roll or store cable reels without an appropriate underlay.

EE. Firestop the insides of all sleeves through fire rated barriers with a UL approved system after cable installation is complete.

FF. Test, label, and document final horizontal cable installation including outlet numbering on as-built drawings.

GG. Remove existing cable and terminations that will no longer be used as specified and shown on project drawings. Coordinate as necessary with electrical contractor for removal of existing horizontal cable pathways and outlet boxes.

HH. A single gang vertical cover shall be installed for securing voice and data patch connections at such locations as kiosks, as shown on the project drawings. The cover shall be drilled out allow an RTD padlock to be installed.

3.02 COPPER CABLE TERMINATION

A. Terminate all pairs on both ends of each copper UTP horizontal cable on the jack with TIA T568B pinpair assignments per manufacturer's guidelines.

B. With prior written approval from RTD IT only, match existing termination practice for horizontal cables to 66-type blocks, with only 3 pair terminated in most existing terminals on 66-type connects. Install bridge clips on each pair tip and ring on 66-type blocks.

C. All cables shall be terminated so as not to pull tight on the terminating equipment.

3.03 INSIDE FIBER OPTIC HORIZONTAL CABLING

A. Perform termination of multimode fiber strands on SC and LC connectors with loss \leq 0.5 dB at 850 nm.

B. Perform termination of singlemode fiber strands SC and LC connectors with loss \leq 0.2 dB at 1310 nm

C. Perform fusion splices for singlemode fiber strands on pigtails with splice loss \leq 0.2 dB at 1310 nm.

D. Perform fusion splices for multimode fiber strands on pigtails with splice loss \leq 0.3 dB at 850 nm.

E. At the work area outlet, place the SC or LC connectors with terminated fiber cable strands in the keystone adapter jacks in the faceplate.

F. Fiber schematics for termination of horizontal fiber strands in the fiber enclosures will be provided by RTD IT.

G. In the TR, ER, or Comm Huts place the SC or LC connectors with terminated fiber cable strands in the adapter panels in the termination shelf as shown on the fiber schematics and per manufacturer's specifications and color sequence. Splice kits or wallets shall be used within the fiber enclosures to support pigtail splices within fiber enclosures, per manufacturer's specifications.

H. All cables shall be terminated so as not to pull tight on the terminating equipment.

I. Field Splices and terminations other than hot Fusion or epoxy/polish are not acceptable.

SECTION 27 15 23

COMMUNICATIONS OPTICAL FIBER FOR HORIZONTAL CABLING

PART 1 GENERAL

1.01 SCOPE OF WORK

- D. This specification includes Buffered Optical Fiber Cables for Indoor Distribution Applications.
- E. Optical fiber cabling for horizontal building fiber applications.
- F. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified by RTD IT, and in performing the following operations recognized as necessary for the installation, termination, and labeling of horizontal optical fiber infrastructure as described on the drawings and/or required by these specifications.
 1. Installation, splicing, termination, testing, labeling and documentation of new inter building fiber optic communication cable between buildings, com houses, and com cases as specified and on the drawings.
 2. The installation environment could include tie in and coordination with existing and new optical fiber and copper facilities, direct-buried conduit, and railway pathways.
 3. The Contractor shall be responsible for: placement of cable, installation and attachment of cable to support devices within the system, the placement of conduit, the installation of pull-boxes, the furnishings of fiber optic splice closures, and installation of termination hardware, and other as specified by RTD IT.
 4. Contractor shall be responsible for providing and installing grounding and bonding materials, and fire stopping materials as required completing the installation.
 5. Other incidental hardware and appliances, necessary for the proper performance and operation of the communication cable system, which are consistent with the practices of cable installation, are to be provided by the Contractor as required to complete the installation.
 6. Contractor is responsible to ensure that utility locating has been performed as per the requirements of RTD cable Location Specifications. The Contractor is responsible for any damages to any utility caused during construction.
 7. Contractor is responsible to provide RTD IT, upon completion of the project an itemized spreadsheet of all Fiber, Products, and materials for RTD IT Asset management.

1.02 RELATED SECTIONS

- A. Section - 27 05 28
- B. Section - 27 11 00
- C. Section - 27 13 00
- D. Section - 27 13 00
- E. Section - 27 13 23
- F. Section - 27 16 19

1.03 REFERENCES

- A. ANSI/TIA-526-14-C - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant, Fiber-Optic Communications Subsystem Test Procedures.
- B. ANSI/TIA 568.3-D - Optical Fiber Cabling Components
- C. FOTP-3 - Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components
- D. FOTP-25 - Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies
- E. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test

- F. FOTP-37 - Fiber Optic Cable Bend Test, Low and High Temperature
- G. FOTP-38 - Measurement of Fiber Strain in Cables Under Tensile Load
- H. FOTP-85 - Fiber Optic Cable Twist Test
- I. FOTP 104 - Fiber Optic Cable Cyclic Flexing Test
- J. EIA/TIA-598 - Optical Fiber Cable Color Coding.
- K. ICEA S-83-596 - Standard for Fiber Optic Premises Distribution Cable
- L. NFPA 70 - National Electric Code (NEC)
- M. ANSI/UL 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
- N. ISO 11801 - Generic Cabling for Customer Premises

1.04 DESIGN / PERFORMANCE REQUIREMENTS

- A. Structured cabling system shall be able to support interconnections to active telecommunications equipment for voice and data applications in a multi-vendor, multi product environment. Structured cabling system should adhere to ANSI/TIA 568 B; 569-A; 606-A; J-STD-607-A and TIA 942 standards with respect to pathways, distribution, administration, and grounding of the system. Structured cabling system be installed in accordance to local codes and regulations.
- B. Floor serving active data equipment will be interconnected to the facility serving data equipment via a fiber backbone terminated in rack mounted enclosures which will utilize SC or LC connections. This will serve to connect the Main Telecommunications Room to an additional Telecommunications Room serving the locations that exceed the distance limitations (90 meters) of the Main Telecommunications Room for the horizontal Data and Voice drops.
- C. Metallic hardware used in fiber optic cabling systems (such as wall-mounted termination boxes, racks, and patch panels) must be grounded in accordance with ANSI/TIA/EIA 607, NECA-BICSI-568.

1.05 SUBMITTALS

- C. Product Data: Manufacturer's data sheets on each product to be used, including:
 1. Storage and handling requirements and recommendations.
 2. Installation procedures and technical support concerning the items contained in this specification.
- D. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be ISO9001, TL9000 and/or ISO14001 registered, for quality assurance.
- B. Regulatory Requirements: Conform to all applicable codes and ordinances for flame, fuel, smoke and volatile organic compounds (VOC) ratings requirements for finishes at time of application.
- C. Fiber Optical Cable: All optical fibers in cables lengths of 300 m or greater shall be 100% attenuation tested. Attenuation shall be measured at 850 nm and 1300 nm for Multimode and 1310 nm and 1550 nm for Single-mode. Manufacturer shall store a record of these values for a minimum of 5 years and the recorded values shall be available upon request.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handle and store products in accordance with the manufacturer's requirements. Store in manufacturer's unopened packaging with all labels intact until ready for installation.
- B. Package completed cable for shipment on non-returnable wooden reels. Required cable lengths shall be stated in the purchase order.
 1. Top and bottom ends of the cable shall be available for testing.
 2. Both ends of the cable shall be sealed to prevent the ingress of moisture.

3. Each reel shall have a weather resistant reel tag attached identifying the reel and cable.
- C. Package cable in cartons and/or wound on spools. Each package shall contain only one continuous length of cable. Construct packaging to prevent damage to the cable during shipping and handling.
- D. Securely fasten the outer end of the cable to the reel head to prevent the cable from becoming loose in transit. Inner end of the cable shall project into a slot in the side of the reel or into a housing on the inner slot of the drum, in a manner and of sufficient length to make it available for testing.
- E. Test tails shall be at least two meters long. Fasten the inner end to prevent the cable from becoming loose during shipping and installation.
- F. Reel Marking and Labeling. Every cable reel be marked as follows:
 1. Reel Label:
 - a. Part number
 - b. Reel number
 - c. Length (ft/m)
 - d. Marking (ft/m) top and bottom
 - e. Date of manufacture
 - f. Listing information
 2. Bar Code Label:
 - a. Package ID
 - b. Reel number
 - c. Quantity
 - d. Customer ID
 - e. Package count
 - f. Factory order number
 - g. Release part number
 - h. Length (ft)
 - i. "Ship to:" address
 3. Stenciling:
 - a. Manufacturer's name and address
 - b. Direction of rotation
 - c. Reel size
 - d. "DO NOT LAY REEL ON SIDE"

1.08 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturer: Corning Optical Communications LLC, which is located at: 800 17th St. NW; Hickory, NC 28601; Toll Free Tel: 800-743-2675; Tel: 828-901-5000.
Email: [request info \(eliteadvan@corning.com\)](mailto:request_info(eliteadvan@corning.com));
Web: <http://www.corning.com/worldwide/en/products/communication-networks/products.html>
- B. Requests for substitutions will be considered, substitution requests shall include all required product data and shall be complete with reasons for substitutions and savings, which will accrue to RTD if substitutes are approved. Substitutes will be considered only if equal or superior to that specified.

- C. All Fiber, Products, and materials turned over to RTD in the project provided will be itemized and entered in a spreadsheet to be turned over to RTD IT Asset management.

2.02 BUFFERED OPTICAL FIBER CABLES FOR HORIZONTAL INDOOR DISTRIBUTION

A. General:

1. Cable shall meet the requirements of the National Electrical Code (NEC) Section 770:
 - a. Non-Plenum Applications: Applicable Flame Tests: ANSI/UL 1666. Cables shall be listed OFNR.
 - b. Finished cables shall be tested to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Fiber Optic Premises Distribution Cable (ICEA S-83-596).
2. Cable shall be all-dielectric.

B. Fiber Specifications:

1. Detailed information on the cabled performance of the fiber types available for this cable design shall be found in the following manufacturers specifications:
 - a. Dispersion Un-shifted Single-mode Fiber: Corning Generic Specification F3, "Generic Specification for Single-mode Optical Fiber in Tight Buffer Cables."
 - b. 50/125 µm and 62.5/125 µm Multimode Fiber: Corning Generic Specification F4, "Generic Specification for Multimode Optical Fiber in Tight Buffer Cables."

C. Cable Construction:

1. All fibers, except white, shall be colored with ultraviolet (UV) curable inks. Fibers occupying the white position shall be left uncolored.
2. All fibers shall be coated with a low friction slip layer.
3. Coated fibers shall be buffered with a thermoplastic compound to a diameter of 900 ± 50 SYMBOL 109 "Symbol" 10m.
4. Individual fiber's 900 µm buffer coating shall be color coded for identification. Color coding shall be in accordance with EIA/TIA-598, "Optical Fiber Cable Color Coding." Coloring material shall not be susceptible to migration and shall not affect the transmission characteristics of the optical fibers. Color-coded buffered fibers shall not adhere to one another. Buffered mechanical fibers in filler subunits, where used, shall be white (natural).
5. When buffered fibers are grouped into individual subunits, each subunit jacket shall be numbered for identification, with the exception of filler subunits where used. Numbers shall be repeated at regular intervals.
6. Fiber coating and buffer shall be removable with commercially available stripping tools in a single pass for connectorization or splicing.

D. Cable Core Construction: Strength members shall consist of high modulus strength yarns. Strength yarns shall be helically stranded around the buffered fibers. Non-toxic, non-irritant talc shall be applied to the yarns to allow them to be easily separated from the fibers and the jacket.

1. Non-unitized Cables, 2 to 24 Fibers: Fiber shall be stranded around a dielectric strength element and surrounded by layered strength yarns. Strength element shall be overcoated with a thermoplastic, when required, to achieve dimensional sizing to accommodate and support the 900 µm buffered fibers. Cables having 12 to 24 fibers shall be dual layered. Strength yarns shall serve as the tensile strength members of the cable. A ripcord may be applied between the strength yarns and the outer jacket to facilitate jacket removal. An outer jacket shall be extruded over the strength yarns for physical and environmental protection.
2. Unitized Cables, 24 to 72 Fibers: Buffered fibers shall be grouped in six fiber subunits. In each subunit, individual fibers shall be stranded around a dielectric strength element and surrounded by layered strength yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. Subunit jacket shall be extruded over the strength yarns for additional physical and environmental protection. Subunits shall be stranded around a dielectric central member. A ripcord shall

be inserted beneath the outer jacket to facilitate jacket removal. An outer jacket shall be extruded around the subunits.

3. Unitized Cables, 72 to 144 Fibers: Buffered fibers shall be grouped in twelve fiber subunits. In each subunit, the individual fibers shall be stranded around a dielectric strength element and surrounded by layered strength yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. Subunit jacket shall be extruded over the strength yarns for additional physical and environmental protection. Subunits may be stranded around a dielectric central member. Cables may contain filler subunits to provide symmetry to the cable design. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. An outer jacket shall be extruded around the subunits.

E. Cable Jacket:

1. Jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. Jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. Jacket shall be smooth, as is consistent with the best commercial practice. Jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
2. Nominal thickness of the cable outer jacket shall be sufficient to provide adequate cable protection while meeting the mechanical, flammability, and environmental test requirements of this document over the life of the cable.
3. Cable jacket and subunit jacket color shall be orange for cables/subunits containing multimode fiber except for cables/subunits containing 50/125 μ m Laser Optimized Fiber, which shall have an aqua colored jacket. Cable/subunit jacket color shall be yellow for cables containing single-mode fiber.
4. Outer cable jacket shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet (e.g., "CORNING OPTICAL CABLE - MM/YY - 12 SME - EOS - OFNR FT4 c(ETL)us 00001 FEET"). Marking shall be in contrasting color to the cable jacket.

F. Cable Performance:

1. Temperature Range:
 - a. Storage temperature range for cable on the original shipping reel shall be -40 degrees C to +70 degrees C.
 - b. Installation temperature range for riser cables shall be -10 degrees C to +60 degrees C.
 - c. Operational temperature range for riser cables shall be -20 degrees C to +70 degrees C. Testing shall be in accordance with FOTP-3.
2. Crush Resistance:
 - a. When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," cable shall withstand a minimum compressive load of 100 N/cm (57 lbf/in) applied uniformly over the length of the compression plate.
 - b. While under compressive load, the fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).
3. Cyclic Flexing:
 - a. When tested in accordance with FOTP 104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 \pm 1 cycles per minute.
 - b. Fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode). J
 - c. Jacket shall not crack, split, or tear.
4. High and Low Temperature Bend:
 - a. When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," cable shall withstand four full turns around a mandrel at an installation temperatures of -10 degrees C and +60 degrees C. Mandrel diameter shall be the greater of 20 times the cable OD or 150 mm.
 - b. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).
5. Impact Resistance:

- a. When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," cable shall withstand a minimum of 2 impact cycles at 3 locations spaced a minimum distance of 150 mm. Impact energy shall be 2.94 Nm.
 - b. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).
 - c. Jacket shall not crack, split or tear.
6. Temperature Cycling:
- a. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after the second cycle at extreme operational temperatures (-20 degrees C and +70 degrees C) shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). Change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling.
7. Twist-Bend:
- a. When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting and bending.
 - b. Fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or 0.60 dB at 1300 nm (multimode).
8. Tensile and Fiber Strain:
- a. When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, "Measurement of Fiber Strain in Cables Under Tensile Load," a length of cable shall be tested to the rated tensile load.
 - b. For cables < 12f the rated tensile load is 660 N (148 lbf) and for cables > 12f the rated tensile load is 1320 N (297 lbf).
 - c. While under rated tensile load, fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load), the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).
 - d. After the tensile load is removed, fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single mode) or greater than 0.60 dB at 1300 nm (multimode).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until support structures and substrates have been properly prepared.
- B. Verify installation of the fiber optic cable backbone cabling Specified is Section 27 13 23.
- C. Verify installation of support structures for horizontal fiber optic cable before the installation.
- D. Do not install a fiber optic cable in a conduit or duct that already contains cabling, regardless of the cable type.
- E. Remove abandoned cables unless unused cables are reserved for future use or cable that is not terminated at equipment other than a connector and not identified for future use with a tag as required by the National Electrical Code.
- F. If support structures and substrate preparation are the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 INSTALLATION

- A. General: Cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification.

B. Testing and Acceptance:

1. All cables shall be tested according to the requirements of ANSI/TIA 568.3-D. Any defects in the cabling, connectors, couplers or patch panels shall be repaired or replaced in order to ensure 100% useable fiber in all cables installed.
2. For horizontal cabling system using multimode optical fiber, attenuation shall be measured in one direction at either 850 nanometer (nm) or 1300 nm using an LED light source and power meter using an encircled flux (EF) compliant reference jumper per ANSI/TIA-526-14-C.
3. If performing Tier II testing with an OTDR, fiber cabling shall be tested at both 850 nm and 1300 nm for Multimode or 1310 nm and 1550 nm for single mode. This should be a bi-directional test that averages the values to compensate for any mode field mismatch.

3.03 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

3.04 SCHEDULES**A. Tight-Buffered:**

1. MIC Tight Buffered, Plenum; Corning Generic Spec PGS049
2. MIC Tight Buffered, Interlocking Armored, Plenum; Corning Generic Spec PGS049
3. MIC Unitized Tight Buffered, Plenum; Corning Generic Spec PGS049
4. MIC Unitized Tight Buffered, Interlocking Armored, Plenum; Corning Generic Spec PGS049
5. Reel-In-A-Box, MIC Tight Buffered, Plenum; Corning Generic Spec PGS049
6. MIC DX Tight Buffered Armored, Plenum; Corning Generic Spec PGS091

B. Ribbon:

1. Ribbon, Plenum; Corning Generic Spec PGS043
2. Ribbon, Interlocking Armored, Plenum; Corning Generic Spec PGS043
3. Ruggedized Ribbon, Plenum; Corning Generic Spec PGS043
4. UltraRibbon Indoor, Gel-Free, Plenum; Corning Generic Spec PGS043
5. LSZH Ribbon; Corning Generic Spec PGS056
6. LSZH UltraRibbon Indoor Gel-Filled; Corning Generic Spec PGS056
7. LSZH UltraRibbon Indoor Gel-Free; Corning Generic Spec PGS056
8. Fan-out, Tight Buffered, Plenum; Corning Generic Spec PGS017

C. Loose Tube:

1. Mining and Petrochemical Tray-Rated, Loose Tube, Gel-Free; Corning Generic Spec PGS116

D. Hybrid:

1. ActiFi DAS for Indoor Plenum; Corning Generic Spec PGS130
2. ActiFi DAS Interlocking Armored Cables for Indoor Plenum; Corning Generic Spec PGS130
3. ActiFi Tight-Buffered Cables, Plenum; Corning Generic Spec PGS130

SECTION 27 16 00**COMMUNICATIONS CONNECTING CORDS, DEVICES, AND ADAPTERS****1.01 COPPER PATCH CORDS FOR CATEGORY 6 LINES**

- A. Telecommunications Contractor will be required to provide (2) Category 6 patch cords per Category 6 line installed.

1. The specific number of provided patch cords will be determined by the number of completed drops in the project; this includes any change order

a. 1 per installed drop- appropriate combination of cordage lengths to equal 1 per installed drop Category 6 patch cord. Combination of lengths should be relevant to the patch panel position and rack units used, as well as equipment location and rack placement.

b. 1 per installed drop- 15' Category 6 patch cord

B. Because UTP cable is protected from cross talk and immunity from EMI through the cables pair twist and lay configuration, care must be taken to maintain the minimum bend radius (4 times the cable diameter) of the copper patch cords. All furnished patch cords must be certified by the manufacturer to match the cable type used in the horizontal distribution.

C. Field terminated patch cords are not acceptable. It has been common practice to assemble patch cords in the field using leftover solid-conductor cable. Field assembled patch cables will not perform to Category 6 standards, frequently do not perform to Category 5 standards, and cannot be tested for proper performance using currently available field testing equipment. Patch cables shall always be made from stranded copper wire to withstand the flexing associated with patch cords. Any existing field assembled patch cords shall be replaced with factory assembled Category 6 patch cords. Do not attempt to use Category 5 patch cords for Category 6 connections.

D. Telecommunications Contractor will be required to provide (1) fiber optic patch cord per termination. The fiber optic patch cord will be consistent with termination type and fiber optic mode. (i.e. singlemode or multimode)

SECTION 27 16 19

PATCH CORDS, STATION CORDS AND CROSS CONNECT WIRE

A. Cross-connects in the TR, ER, And Comm Huts will be done by using patch cords to connect a jack on the horizontal cabling system Category 6A patch panel to the appropriate service connector or electronics. RTD IT will install all data equipment cables and patch cords used in the TR, ER, And Comm Huts for data connectivity and install them as well as the network equipment. The cost for the patch cables will be included in the total cost for all IT equipment specified by RTD IT.

B. Voice cross-connects for dial tone will be made here using standard cross connect wire. All voice system cross-connects will be done by RTD IT. Any other system cross-connects must be clearly labeled, identified and provided by that system provider.

C. Because UTP cable is protected from cross talk and immunity from EMI through the cables pair twist and lay configuration, care must be taken to maintain the minimum bend radius (4 times the cable diameter) of the copper patch cords. All patch cords must be certified by the manufacturer to match the cable type used in the horizontal distribution.

D. Field terminated patch cords are not acceptable. Field assembled patch cables will not perform to Category 6A standards, frequently do not perform to Category 5 standards, and cannot be tested for proper performance using currently available field-testing equipment. Patch cables shall always be made from stranded copper wire to withstand the flexing associated with patch cords. **Any existing field assembled patch cords shall be replaced with factory assembled Category 6A patch cords. Do not attempt to use Category 5 patch cords for Category 6A connections.**

SECTION 27 17 00

TESTING, IDENTIFICATION AND ADMINISTRATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings, Contract Forms, and Conditions of the Contract, including, but not limited to, RTD IT Manager/General Contractor Agreement, Exhibits and other Division 1 Specifications, apply to this section.

1. Section 27 08 10 – Optical Fiber Testing and Measurements

1.02 SCOPE OF WORK

A. Provide all services, labor, materials, tools, and equipment required for complete and proper testing, certification, identification, and administration of the installed telecommunications cabling as called for in these specifications and related drawings.

B. This section includes minimum requirements and installation methods for the following:

1. Copper UTP Cable Testing and Testers
2. Fiber Optic Cable Testing and Testers
3. Coaxial Cable Testing and Testers
4. Labels and Labeling
5. Documentation

1.03 QUALITY ASSURANCE

A. All testing procedures, testers, identification, and administration work shall comply with the specifications and all applicable requirements of the most recent versions of the following standards, including all applicable addenda:

1. ANSI/TIA-568-C.0 – Generic Telecommunications Cabling for Customer Premises
2. ANSI/TIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
3. ANSI/TIA-568-C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standard
4. ANSI/TIA-568-C.3 – Optical Fiber Cabling Components Standard
5. ANSI/TIA-568-C.4 – Broadband Coaxial Cabling and Components Standard
6. ANSI/TIA-569-D – Telecommunications Pathways and Spaces
7. ANSI/TIA-598-D – Optical Fiber Cable Color Coding
8. ANSI/TIA-606-B – Administration Standard for Telecommunications Infrastructure
9. TIA-455 Series – Standard Test Procedures for Optical Fibers, Cables, Transducers, Connecting and Terminating Devices
10. TIA-526 Series – Standard Test Procedures for Fiber Optic Systems
11. ANSI/TIA-606-B – Administration Standard for Commercial Telecommunications Infrastructure
12. TSB 140-04 – Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems
13. BICSI Telecommunications Distribution Methods Manual
14. BICSI Telecommunications Cabling Installation Manual
15. RTD IT Standards for Identification and Administration

B. Testing shall be performed by trained technicians who have successfully attended appropriate training programs for optical fiber test equipment being used, and have obtained certificates as proof thereof.

1.04 SUBMITTALS

A. Manufacturer's catalog sheets and specifications for field-test instruments.

B. Documentation of current calibration for optical fiber test instruments.

- C. Training certificates for technicians performing optical fiber testing.
- D. Final verified As-Built T-5 Jack Numbering Position Sheet as specified
- E. Final verified As-Built Drawings as specified.
- F. Final verified As-Built Test Reports as specified.

PART 2 – MATERIALS

2.01 COPPER UTP CABLE TESTERS

- A. Test equipment and field test instruments shall meet current applicable ANSI/TIA requirements.
- B. Physical interface shall be modular RJ-45 connector and a serial port with DB-9 connector.
- C. Store test results including date stamp of tests and RTD IT jack designator for each tested link.
- D. Provide standard test reports in pdf format with both summary and individual test results for tested cables.
- E. Have auto-testing to determine if cable meets requirements of ANSI/TIA standards for 10Base-T, Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet.

2.02 OPTICAL FIBER CABLE TESTERS

- A. Field test instruments shall be within the calibration period recommended by the manufacturer.
- B. Field test instruments for multimode fiber cabling shall meet the requirements of ANSI/TIA/EIAA-526-14.
- C. Field test instruments for singlemode fiber cabling shall meet the requirements of ANSI/TIA/EIAA-526-7.
- D. Optical Loss Test Set (OLTS) Multimode Fiber Light Source
 1. Provide dual stabilized LED light sources with central wavelengths of 850 nm (± 30 nm) and 1300 nm (± 20 nm).
 2. Output power of -20 dBm minimum.
 3. The light source shall meet the launch requirements of ANSI/TIA 526-14-B including Encircled Flux.
 4. Spectral width of sources shall be ≤ 50 nm of 850 nm wavelengths and ≤ 140 nm for 1300 nm wavelengths.
 5. Output stability ± 0.40 dB from 0 to 50 degrees C.
 6. Long term output stability ± 0.10 dB at 25 degrees C.
 7. Connector types shall include: ST, SC, and LC
- E. OLTS Singlemode Fiber Light Source
 1. Provide dual stabilized laser light sources with central wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
 2. Output power of -10 dBm minimum.
 3. Output stability ± 0.40 dB from 0 to 50 degrees C.
 4. Long term output stability ± 0.10 dB at 25 degrees C.
 5. Connector types shall be ST, LC, LC-APC, and SC-APC.
- F. OLTS Power Meter
 1. Provide 850 nm, 1300/1310 nm, and 1550 nm selectable wavelength test capability.
 2. Power measurement uncertainty of ± 0.25 dB.
 3. Store reference power measurement.
 4. PC interface (serial or USB).
 5. Connector types shall include: ST, SC, LC, LC-APC, and SC-APC.
- G. Optical Time Domain Reflectometer (OTDR)
 1. Selectable Cable Index of Refraction
 2. Visual fault locator for continuity checks and dead zone fault location
 3. Equipped with launch jumper cable of sufficient length to offset entry "dead zone"
 4. Multimode requirements:
 - a. Dual selectable wavelengths of 850 nm (± 20 nm) and 1300 nm (± 20 nm).
 - b. Event dead zones of 3.7 m maximum at 850 nm and 1300 nm.

- c. Attenuation dead zones of 10 m maximum at 850 nm and 13 m maximum at 1300 nm.
- d. Distance range not less than 2000 m.
- e. Dynamic range at least 10 dB at 850 nm and 1300 nm.

5. Singlemode Requirements:

- a. Dual selectable wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
- b. Event dead zones of 3.5 m maximum at 1310 nm and 1550 nm.
- c. Attenuation dead zones of 10 m maximum at 1310 nm and 12 m maximum at 1550 nm.
- d. Distance range not less than 10000 m.
- e. Dynamic range at least 10 dB at 1310 nm and 1550 nm.

6. Connector types shall include: ST, SC, LC, LC-APC, and SC-APC.

H. Fiber Microscope

- 1. Magnification of 200X or 400X for end face inspection. May be combined into one instrument with the OTDR.

2.03 COAXIAL CABLE TESTERS

- A.** Field test equipment shall be capable of testing and measuring both analog and digital QAM.
- B.** Field test equipment shall be capable of testing up to 1 GHz..

2.04 LABELS

- A.** Faceplate labels shall be printed and supplied by the Contractor with an electronic label maker.
- B.** All jacks in new patch panels shall be labeled using labeling software and labels available from the patch panel manufacturer.
- C.** The one-page Copper Termination Sheet and Fiber Termination Labels will be provided and installed by RTD IT. All additional labels needed shall be supplied and installed by the Contractor.
- D.** Labels for cable marking: vinyl substrate with a white printing area and double sided to be installed as a cable flag type of label. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow - so that the labels are easily distinguishable.
- E.** Pre-printed labels shall meet legibility, defacement, exposure and adhesion requirements of UL 969.
- F.** Hand written labels are not allowed.
- G.** Cable ID tags shall be provided and installed by the Contractor on all backbone cables.

PART 3 - EXECUTION

3.01 CABLE TESTING

- A.** Final testing shall be scheduled and conducted in the presence of the RTD IT representative as specified
- B.** All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
- C.** Complete and submit electronic test results for all UTP copper and fiber optic cabling prior to scheduling the final testing with RTD IT.
- D.** Testing for UTP copper and fiber optic cabling shall be performed on each cabling segment (connector to connector).
- E.** Any link that fails testing shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link meets performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation.

3.02 COPPER UTP CABLE TESTING

- A.** Test 100% of installed backbone copper cabling for:
 - 1. Wire Map

2. Length

B. Perform the following Permanent Link tests for 100% of installed copper horizontal cabling as described in applicable ANSI/TIA-568 standards:

1. Wire Map
2. Length
3. Insertion Loss
4. Pair-To-Pair NEXT Loss
5. Propagation Delay
6. Delay Skew

C. Perform the following Permanent Link tests for 100% of installed Category 5e, Category 6, and Category 6A horizontal copper cabling as described in applicable ANSI/TIA-568 standards:

1. PSNEXT Loss
2. Pair-To-Pair ELFEXT
3. PSELFEXT
4. Return Loss

D. Cross-connects from horizontal to backbone cabling will not be in place for these tests.

E. The wire map test shall verify pair to pin termination at each end and check for connectivity errors. The wire map shall indicate the following for each of the eight conductors:

1. Continuity to the remote end
2. Shorts between any two or more conductors
3. Reversed pairs
4. Split pairs
5. Transposed pairs
6. Any other miswiring

F. The maximum length of the permanent link for horizontal cable shall be 90 meters. Shorten any cable runs as required at no additional cost to RTD.

G. Replace and or repair cable and terminations as necessary to assure 100% passing performance specifications.

H. Submit electronic test reports in standard pdf format for each copper cabling permanent link to RTD IT before project is closed.

3.03 OPTICAL FIBER CABLE TESTING

A. Testing shall be performed using high-quality test cords of the same fiber type as the cabling under test.

1. Section 27 08 10

B. Perform link attenuation (OLTS) testing of all installed multimode fiber optic strands after splicing and termination in accordance with current ANSI/TIA standards.

1. One direction with an optical light source and an optical power meter.
2. Test at two wavelengths to account for attenuation differences due to wavelength:
 - a. 850 nm and 1300 nm for multimode strands
 - b. 1310 nm and 1550 nm for singlemode strands
3. Test multimode strands in accordance with TIA-526-14, One Reference Jumper with Encircled Flux.
4. Test Singlemode strands in accordance with TIA-526-7, One Reference Jumper.
5. Test cords for link attenuation testing shall be between 1 m and 5m in length.
6. The total attenuation budget for each fiber cable length (end-to-end) shall be calculated by the following formula:

a. Link Attenuation (dB) = Cable Attn (dB) + Connector Attn (dB) + Splice Attn (dB)

b. Cable Attn (dB) = Attenuation Coefficient (dB/km) * Length (Km)

c. Connector Attn (dB) = number of connector pairs * connector loss (dB)

d. Maximum allowable connector loss on multimode fiber = 0.5 dB

e. Maximum allowable connector loss on singlemode fiber = 0.3 dB

f. Splice Attn (dB) = number of splices * splice loss (dB)

- g. Maximum allowable splice loss on multimode fiber = 0.3 dB
- h. Maximum allowable splice loss on singlemode fiber = 0.2 dB

C. Polarity Testing:

- 1. Paired duplex fibers in multi-fiber cables shall be tested with an OLTS to verify polarity.

D. Test all installed fiber optic strands after splicing and termination with an OTDR per ANSI/TIA standards:

- 1. End-to-end bi-directional signature trace with fault finding, connection point reflections, fiber bend, pressure point locations, etc. (test results must be turned in for both ends of each strand).
- 2. One wavelength, 1300 nm for multimode strands.
- 3. One wavelength, 1550 nm for singlemode strands.
- 4. The launch cable installed between the OTDR and the first link connection shall be approximately 100 m in length.
- 5. The receive cable installed after the last link connection shall be at least 25 m in length.
- 6. Multimode fiber connector losses shall be \leq 0.5 dB at 1300 nm
- 7. Singlemode fiber connector losses shall be \leq 0.3 dB at 1550 nm
- 8. Multimode fiber splice losses \leq 0.3 dB at 1300 nm
- 9. Singlemode fiber splice losses \leq 0.2 dB at 1550 nm
- 10. Localized attenuation shall not exceed 0.5 dB at any point

E. Magnified End Face Inspection:

- 1. Fibers may be inspected at 250X or 400X magnification for end face quality. 250X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers.
- 2. Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Fibers that are broken or damaged shall be replaced at no cost to RTD and replaced fiber optic cables shall be re-tested.

G. Submit electronic OTDR test results reports for each fiber optic cable strand to RTD IT before project is closed.

3.04 CABLE IDENTIFICATION AND LABELING:

A. Neatly and permanently label all copper and fiber optic backbone cables with the cable number at both ends.

B. The RTD standard outlet numbering plan to be used for labeling faceplates, 66-blocks, patch panels, and fiber terminations is described in 3.05 D **Labeling and Testing.**

C. Fiber schematics for termination of backbone and horizontal fiber strands in the fiber enclosures will be provided by RTD IT. Fiber cables shall be labeled following the numbering shown on the fiber schematics.

D. The identification and labeling for all copper and fiber optic cables and TR, ER and Comm Hut terminations shall be clearly labeled and approved by RTD IT prior to scheduling final testing with RTD IT.

E. The "FIBER OPTIC CABLE" tags must be used in the ER, TR, Comm Huts, tunnels, and manholes, on both sides of all fiber coils and every 8 feet of additional exposed fiber cable.

3.05 AS-BUILT DRAWINGS

A. Mark the project drawings with notations reflecting any variations from the base specifications and drawings including as-built numbering for the outlets on the floorplans.

B. Labeling and Testing Base: This section is an introduction to the numbering of work-area outlets at the RTD (Regional Transportation District). Although RTD numbers the work-area outlets in the database and expects this on the "Jack Position Sheet," not all information is always applied (i.e. on work-area outlet). The numbering for each work-area outlet shall include:

- 1. Communication room number (ER, TR, Comm Hut)
- 2. Position on the panel or block for the station cable in the A position
- 3. Jack position in faceplate – letters A through F for each station cable
- 4. Cable Type for each Jack:
 - a. C3 = category 3
 - b. 5E = category 5e
 - c. C6 = category 6

- d. 6A= Augmented category 6
- e. M5 = multimode 50/125 micron.
- f. M6 = multimode 62.5/125 micron.
- g. S = singlemode

- 5. Position on panel or block for each station cable
- 6. Ownership information for specific types of outlets when applicable

C. Work-Area Outlet: The work-area outlet number on the top of the faceplate will include:

- 1. Ownership information for specific types of outlets when applicable
- 2. Communication room number (ER, TR, Comm Hut)
- 3. Position on the panel or block for the station cable in the A position 1

D. Labeling and Testing

- 1. The left ear of each 66 block will be labeled with the block number (1, 2, 3, etc.).
- 2. All riser cable is punched down only on the left side and will have the riser count on the block for the correct cable pair number starting with the first pair number & every third pair afterwards (i.e. 1, 4, 7, 10, 13, 16, 19, and 22).
- 3. On the right side of the 66 blocks the station cables are labeled at the first pair (w/b) of all station wires with the communication room. The block number and the position and the jack position [A-F] (i.e. 1 – 1A), "RM" for room & the room number the work-area outlet is located in. Work from top to bottom and from left to right.

E. Patch Panel: All patch panels will be labeled on the left side with a letter that designates the panel's position in the rack. Patch panel jacks will be labeled using the same number that is on the work-area outlet faceplate (without the communication room number), followed by the jack association letter. Each jack on the patch panel will be labeled with:

- 1. Rack & panel number, or block number, for the station cable in the A position on the associated work-area outlet faceplate
- 2. Position on the panel or block for the station cable in the A position on the associated work-area outlet faceplate
- 3. Jack position in the associated work-area outlet faceplate for each station cable – letters A through F
- 4. The "RM" with the room number that the work-area outlet is located in

Notes: * All jacks in new patch panels shall be labeled using labeling software and labels available from the patch panel manufacturer.

* Use Dymo Electronic Label-maker 5000 (or equivalent) to print labels for jacks in existing patch panels.

* Hand-written labels are not allowed.

F. Krone Block: Krone blocks will be numbered and terminated left to right per block and left to right per rack. The numbering is similar to the patch panel layout.

- 1. The cable ID and pair count is listed for each pair. *8 Pair Ultim8 Blocks*
- 2. Each block is labeled with the block number and the Riser ID with the pair count on the top label of the *8 pair Ultim8 blocks*.
- 3. Label each *8 pair Ultim8 block* on the front of the top row, as follows:
 - a. Rack & panel number, or block number, for the station cable in the A position on the associated work-area outlet faceplate
 - b. Position on the panel or block for the station cable in the A position on the associated work-area outlet faceplate
 - c. Jack position in the associated work-area outlet faceplate for each station cable letters A through F
 - d. "RM" with the room number that the work-area outlet is located in.

G. 110 Block: 110 Blocks will be numbered per 100-pair on the square next to the first row of each 100-pair.

- 1. Jack ID numbering is similar to the patch panel
 - a. Each station cable will have all 4 pairs terminated and will be labeled Block #, Position # 1-6 per row and up to 24 per block, and room # jack is in the "A" position.

b. If a cable is added to an existing outlet, the cable ID in the TR will need to reflect the faceplate "A" position and faceplate position being added. Example: 1-1B, 1-1C, 1-1D, 1-1E or 1-1F.

2. Riser or tie cable will be labeled every 5th pair and marking the first pair of each 25-pair group.

3. When 110 hardware is used, jacks are not dedicated to a riser count. A cross connect is necessary to connect from a riser pair to a jack.

H. Jack Position Sheets (T-5): T-5 Jack position sheets shall be provided for all projects as specified in Section 27 01 00. The Jack Position sheet shall need to include CAD numbers and room numbers from the floorplan drawings and all fields of data for each work-area outlet and station cable as described in this document.

I. Protectors: The cable count and pairs shall be labeled on each protector (i.e. 11, 1 – 100 broken out for each protector).

J. Riser Copper Sheet: RTD will provide a master list with riser pair counts to be assigned in the MAIN and each TR. All riser pairs will be terminated and labeled according to the Riser Copper Sheet provided by RTD.

K. Backbone Cables: All exposed backbone cables shall be clearly labeled with cable type, cable ID, and pair/strand count before and after every splice, when leaving or entering the building and in communication rooms, tunnels, and all maintenance holes or hand holes.

L. Prior to Test, Check List

1. For all new fiber installs:

- a. Fiber labels
- b. Numbers on 10A/1000SC/LC panels
- c. Racks, shelves and panels properly lettered
- d. Coils permanently mounted
- e. Floor cleaned-up and trash emptied

2. Testing day:

- a. Keys for terminals
- b. Communication devices for testing purposes
- c. Working test equipment

Note: If all the above-mentioned items are not completed, you are not ready to test.

M. Check List (Fiber)

1. For all fiber upgrades and installs:

- a. Place all labels in terminals affected
- b. Label racks, shelves and patch panels correctly
- c. Place cable tags as specified in this document
- d. Place numbers to the left on the 1000 SC/LC panels
- e. Place coupler grooves to the top when installing
- f. Mount fiber coils permanently per print
- g. Clean terminal and empty trash

2. Test Day Bring:

- a. Keys for the terminals
- b. Communication devices for testing purposes
- c. Working test equipment
- d. Two knowledgeable testers and an RTD IT Rep will meet you at the location

NOTE: If all the above-mentioned items are not completed, you are not ready to test!

N. Check List (Copper)

1. For all copper upgrades and installs:

- a. Place all new copper sheets in terminals affected
- b. Label racks, shelves and patch panels correctly
- c. Place clear plastic covers on all 66 blocks
- d. 66 blocks numbered correctly
- e. Clean terminal and empty trash
- f. Pre-test completed?

2. Test Day Bring:

- a. Keys for the terminals
- b. Floorplans
- c. Updated T-5 Jack Position Sheets
- d. Communication devices for testing purposes
- e. Working test equipment
- f. Two knowledgeable testers and an RTD IT Rep will meet you at the location

NOTE: If all the above-mentioned items are not completed, you are not ready to test!

SECTION 27 20 00

DATA COMMUNICATIONS

PART 1 – GENERAL

1.01 DATA COMMUNICATIONS EQUIPMENT

A. Each project supplies funds for all required data communications equipment.

B. The data communications equipment is designed, provided, installed, and configured by RTD IT Network Group unless provided through the contract then RTD IT must pre-approve all designs and products to be installed.

C. The data communications equipment consists of routers, firewalls, switches, access points, power supplies, and Uninterruptible Power Supplies (UPS) required for such equipment. Remote power supplies are not allowed.

1. Each switch will be configured with redundant load sharing power supplies with POE support and capable of sufficient power to handle POE and full stack of blades.

a. Power supplies must be the Manufacture's specified power supply (No Substitutions Allowed).

D. RTD IT Network Group will specify all network equipment necessary for data communications. Budgetary estimate for network equipment and hardware will be determined during the design phase. If this equipment is to be ordered through the contract it must be pre-approved by RTD IT Network Group, and no substitutions will be allowed without written approval from RTD IT Network Group.

1. **Equipment and materials required for installation under these specifications shall be the current model and new (less than one [1] year from date of manufacture), unused and without blemish or defect, and are to be guaranteed to be free from defect for a minimum of one year from date of project's substantial completion.**
2. The Designer shall coordinate equipment needs with RTD IT during design to help determine electrical loads, UPS sizing and mechanical loads. Designer shall coordinate the electrical and mechanical loads with the appropriate Design engineers as early in the design process as possible

E. Products that the Contactor is proposing to use that are identical to what has Previously been used on an RTD project can be submitted for Approval in a table that lists the function, manufacturer, and model number of the product for approval. Simply because a product has been previously used on the RTD system does not obligate RTD IT to Approve its use on this Project.

F. Wattage calculations of POE usage on switch locations not to exceed 50% of switch POE capabilities, unless otherwise approved by RTD IT.

G. Each equipment rack shall have at minimum, one (1) dedicated 120V, 20A, non-switched, ac quad electrical receptacle, each on a separate branch circuit, installed in the bottom of each equipment rack to support rack-mounted uninterruptible power supply(s) (UPS). In addition, at minimum a dedicated 208V/20A, NEMA L6-20 receptacle shall be mounted adjacent to the above described 120V receptacle. The final size and type of UPS may affect the exact electrical receptacle type required. Designer shall coordinate this with RTD IT early in the design phase. Up-size electrical wiring to support at minimum 30 amps to allow the flexibility to up-size outlets in the future

SECTION 27 21 33

DATA COMMUNICATIONS WIRELESS ACCESS POINTS

PART 1 – GENERAL

1.01 DATA WIRELESS ACCESS COVERAGE

A. For New Construction projects, it is the responsibility of the consultant to provide wireless and heat maps for the placement of Wireless Access Point locations. Wireless WAP locations shall be cabled using a square cell topology. Provision for one Wireless Access Point (WAP) for every 20 people (30-40 devices) based on occupancy rate of the area. RTD Only uses Wireless Access Points / Wi-Fi in Conference and Break Rooms, Other locations must receive written approval from RTD IT.

1. Location of the wireless device is based on the room design:
 - b. Standard ceiling height rooms with drop tile ceiling: hang the wireless device from the ceiling grid, connected to a 2-port surface mount box, concealed above the drop tile ceiling on an SMB hanger, suspended by dedicated ceiling wire or pencil rod. Utilize a varying length patch cord to optimize signal coverage. Place the surface-mount block and hanger where it may initially provide the greatest amount of useable coverage.
2. For Major and Minor Renovation projects, consult the RTD IT for determination of wireless scope.
3. Wireless network equipment shall be provided by the RTD IT unless the equipment is to be ordered through the contract it must be pre-approved by RTD IT Network Group, and no substitutions will be allowed without written approval from RTD IT Network Group.

SECTION 27 32 00

COMMUNICATIONS EMERGENCY TELEPHONE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. The Contractor shall furnish and install an IP to analog, Emergency Telephone System for two-way emergency voice communications between RTD patrons and RTD Operation and Security Staff. Using IP, the Emergency Telephone equipment shall communicate over the RTD IT portion of the Communication Transmission System (CTS) to establish connectivity between the Emergency Telephones (ETELs) and the existing RTD Emergency Telephone System. The Contractor shall provide additional hardware and licensing to integrate the Emergency Telephone System into the existing RTD Telephone System. The existing RTD Telephone System consists of Session Initiating Protocol (SIP) Servers and an Avaya 8720 PBX.

B. Telephone sets which the Contractor shall, furnish, install and test include:

1. GAI-Tronics Station emergency telephones with handsets, AC powered blue light, stanchions, and wall mounted units.
2. GAI-Tronics elevator emergency telephones without handset will be installed at the elevator manufacturer. The manufacturer for this elevator will be KONE.

C. RTD EM Phone Equipment shall be designed to meet all requirements of the American Society of Mechanical Engineers elevator phone codes. We require our equipment to comply with any local or state requirements.

1.02 RELATED SECTIONS

- A. Contract Terms and Conditions
- B. Division 01 – General Requirements
- C. SECTION 27 01 00 – Operation and Maintenance of Communications Systems
- D. SECTION 27 08 10 – Optical Fiber Testing and Measurements
- E. SECTION 27 04 00 – Common Work Results for Communications
- F. SECTION 27 05 00 – Pathways for Communications Systems
- G. SECTION 27 08 00 – Communications Systems Commissioning

1.03 REFERENCES AND STANDARDS

A. The Contractor shall install, integrate and test the Communications System to the latest revision and applicable sections at the time of Award of Contract of the following codes and standards:

1. Latest American National Standards Institute /Telecommunications Industry Association/ Electronic Industries Association (ANSI/TIA/EIA) 568-D and TIA/EIA 568-D-0 Standards for Telecommunications Cabling Installation Practices for Commercial Buildings
2. American Society of Mechanical Engineering (ANSI/ASME) - A17.1 - 2007 – Safety Code for Elevators and Escalators
3. American Society of Mechanical Engineers (ASME A17.1-2013/CSA B44 - SECTION 2.27.1.1.6)
4. EIA/TIA - 607 Commercial Building Grounding/Bonding Requirements Standard
5. National Building Industry Consulting Service International (BICSI)
6. Telecommunications Distribution Methods Manual (TDMM)
7. American with Disabilities Act (ADA)
8. ADA Accessibility Guidelines (ADAAG)
9. Uniform Building Code (UBC)
10. Local Building Code
11. Local Electrical Code
12. NFPA 70 - National Electrical Safety Code (NEC)

1.04 QUALITY ASSURANCE

A. Quality assurance planning, implementation and reporting shall be in conformance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, except as modified herein.

1.05 SUBMITTALS

A. Items required to be submitted by the Contractor for Approval as part of the Installation Plan, but are not limited to, the following:

1. A functional block diagram of the Emergency Telephone System
2. Station emergency phone manufacture specifications
3. Station Blue Light stanchion specifications
4. Station Blue Light Wall Mounted specifications
5. Analog to IP, SIP converters specifications
6. Ruggedized IP network switch specifications
7. Specifications of the telephone system cabling
8. Elevator emergency phone manufacture specifications
9. Location of the emergency telephones
10. Text describing each element of the PBX/Telephone System

11. Block and lower level diagrams, intended to show each typical configuration
12. Depiction of all external physical and mechanical interfaces
13. Values for all configurable settings
14. List of all lowest level replaceable units, each with MTBF
15. Cable specification and sources
16. Drawings, expanded to show each location
17. Bill of materials
18. Avaya technician qualifications

PART 2 - PRODUCTS

2.01 GENERAL

- A.** All equipment and materials shall be new, in current production, and shall be the best of their respective kinds, free of corrosion, scratches, or other defects and less than one year from manufacture date.
- B.** The emergency telephones shall be of a robust design and built for a harsh transit environment using materials and workmanship that is able to withstand environmental conditions.

2.02 EMERGENCY TELEPHONE TYPES

- A.** The Contractor shall provide the types of telephones listed below and their respected cut sheets:
1. Transit Hub Parking Facility Freestanding Emergency Telephones. The freestanding emergency phones shall be installed within GIA-Tronics model 234-244 free standing stanchion with an integrated blue light strobe. The total height is approximately 7 feet.
 - a. Shall be GIA-Tronics manufactured telephones with Part No. GTE 08009 or Approved equal. These phones have handsets installed. These emergency phones shall be furnished and installed by Contractor according to the requirements of each Work Order. Pressing a single button shall automatically ring down to RTD Security. The call shall not be disconnected when the button is pressed a second time or when the handset is hung up. The phone shall only disconnect from RTD security when performed by the SCC employee.
 2. Transit Hub Parking Facility Wall-Mounted Emergency Telephones:
 - a. Shall be GIA-Tronics manufactured telephones for parking garage use under Part No. GTE 08009 or Approved equal capable of communicating with existing emergency telephone management system. These phones have handsets installed.
 - b. Pressing a single button shall automatically ring down to RTD Security. The call shall not be disconnected when the button is pressed a second time or when the handset is hung up. The phone shall only disconnect from RTD security.
 - c. The ETEs shall be installed within GIA-Tronics model 234WM wall mount unit and the GIA-Tronics model 234 stanchion unit with an integrated blue light strobe. The drawings detail the location of each model.
 3. Elevator Emergency Telephones:
 - a. Shall be GIA-Tronics manufactured telephones with Part No. 397-001 or Approved equal. These phones do not have handsets installed and will be furnished and installed by the elevator manufacturer. The Contractor is responsible for connecting the Elevator ETEL to the appropriate telephone line provided by the SIP device in the security room.

2.03 FUNCTIONAL REQUIREMENTS

- A.** The Emergency Telephones:

1. Shall be line powered to accommodate distances up to 1200 feet. Line powering devices shall be secured upon a rack shelf in the security room of the parking facility.
2. Emergency Telephones external to the building shall have all wiring routed through a protection equipment terminal (PET) block located within each communication box or in the Security Room backboards. These PETs are for only external ETEs, plaza area level 1 and roof level Wall mounted ETEs. The Contractor shall furnish and install all PET devices.
3. Shall be provided with the capability to de-activate after call completion and after a programmable period of time
4. Activation of the call shall be by push button only. Pushing the call button shall not terminate the call.
5. Call termination shall be by timeout or by the remote end hitting a one-digit code to terminate the call. The timeout setting to terminate the call shall be configured to the maximum allowable setting
6. The Blue Light on the telephone stanchion shall operate from an Approved power source. The light will be operated in a low power mode until a call is initiated. Once the call is initiated the blue light will function as a high-power strobe light. When the call is terminated from the Security Command Center (SCC), the light will cease functioning as a strobe and return to a low power mode of operation.
7. Mounting height shall be compliant with the most current ADA standards but no shorter or wider than existing station emergency telephones.
8. Each telephone shall have a visual indication when a call is placed and another visual indication for when the call is answered.
9. Emergency telephones shall be models designed specifically for the harsh environment encountered in transit systems. The emergency telephones shall have documented evidence of a minimum installed base of 250 sets in similar use in a transit environment.
10. It shall be possible to place calls from a remote facility to each of the telephones as a four-digit extension off of the PBX. Programming of the phones shall be possible by calling from this remote facility.
11. The station emergency telephone calls shall be routed to and handled by RTD Security.
12. Each emergency telephone shall be constructed pursuant to a minimum NEMA 3R rating, be Underwriter Laboratory approved, and FCC approved.
13. Software management system
 - a. Each emergency telephone shall be managed by RTD's existing emergency telephone management system (TMA) that is capable of establishing an automatic connection with each emergency telephone on a pre-arranged schedule. Each phone is automatically tested by the system at least once within a 24-hour period, initiated by either the phone or the telephone management system.
 - b. RTD SCC personnel will configure the existing RTD Security, GAI-Tronics software for all telephones installed as part of this Section that automatically dials and performs diagnostics for each phone on a scheduled basis. The software shall provide an alarm to maintenance personnel if the phone has malfunctioned or is inoperable. It shall be possible to generate reports from the software indicating the status of each telephone monitored.
 - c. Each phone shall be automatically tested by the software management system at least once within a twenty-four-hour period initiated by either the phone or PC.
 - d. The system shall be capable of printing an exception report at designated intervals, highlighting use and malfunctions
 - e. The system shall be capable of archiving reports of normal function, malfunctions, log and archive all call activity at each phone, and
 - f. The system shall identify all call activity by date, time, and type of activity.

B. Elevator Emergency Telephones (ASME A17.1-2013/CSA B44 - SECTION 2.27.1.1.6)

1. The two-way communications means within the car shall include a means to verify operability of the telephone line.
 - a. verification of the telephone line operability shall be automatically performed
 - b. verification may be continuous or periodic
 - c. periodic verification shall be at least on a daily basis
 - d. verification shall not require activation of the two-way communications link(s) If means other than a telephone line (e.g., VoIP, net work, intercom, etc.) is used for the two-way communications, similar verification of this equivalent means shall be performed.
2. If the verification means in 2.27.1.1.6(a) determines that the telephone line or equivalent means is not functional, an audible and illuminated visual signal shall be activated. A minimum of one visual and one audible signal shall be provided for each group of elevators controlled by a "FIRE RECALL" switch.
 - a. The visual signal shall.
 - i. be located at the designated landing in the vicinity of the "FIRE RECALL" switch and visible to elevator user(s)

- ii. be labeled "ELEVATOR COMMUNICATIONS FAILURE" in red letters a minimum of 5 mm (0.25in.) high
- iii. Illuminate intermittently
- iv. continue illuminating intermittently until the telephone line or equivalent means is functional
- b. The audible signal shall.
 - i. be 10 dBA minimum above ambient, but shall not exceed 80 dBA measured at the designated landing "FIRERECALL" switch
 - ii. sound at least once every 30 s with a minimum duration of half a second
 - iii. continue to sound until silenced by authorized personnel or the telephone line or equivalent means is functional
- c. A means to silence the audible signal shall be provided and shall be accessible only to authorized personnel. The signal when silenced shall remain silent for a period of no less than 12 hr or until activated by the next failed periodic verification [see 2.27.1.1.6(a)(3)].
- d. The verification means in 2.27.1.1.6(a) shall continue to monitor the operability of the telephone line or equivalent means while the telephone line or equivalent means is not functional on a continuous basis or periodically with intervals of not more than 5 min.

C. SIP Gateway

1. The Session Interface Protocol (SIP) Gateway audio codes MP124/245/AC/SIP shall be configured to allow an ETEL to initiate a trouble call to RTD's existing Emergency Telephone Management System.

2.04 PBX

A. Additional extension licenses for each of the emergency telephones shall be furnished and installed by the Contractor. RTD's existing PBX is an Avaya model 8720. Avaya PBX programming shall be performed by RTD.

PART 3 - EXECUTION

3.01 DESIGN COORDINATION

- A. The emergency telephone equipment shall be line powered.
- B. The Emergency Telephone System shall have the ability and be fully operable when the parking facility and plaza are in operation and terminated on the existing RTD PBX.
- C. Inspect all equipment for:
 1. Conformance to accepted workmanship standards
 2. Conformance to approved design documents
 3. Proper placement, mounting, orientation and mechanical connections
 4. Correct and secure wiring and cabling terminations and connections
 5. Proper grounding
- D. The Contractor shall:
 1. Furnish and install SIP end devices (analog phones and SIP gateways), configuration will be by the RTD IT Department. The Contractor shall deliver the SIP device to the RTD Project Manager. The model shall be Audiocodes MP124/245/AC/SIP.
 2. Connect the SIP equipment into the IT network in network port provided and configured by RTD IT network group.
 3. Furnish and install extension licenses for each new line on RTD's existing Avaya 8720 PBX.

3.02 INSTALLATION

- A. The Contractor shall install the Emergency Telephone System in accordance with the manufacturer's installation procedures.
- B. Unless otherwise specified, the Emergency Telephone stanchions shall be installed with the front within line-of-site of a closed-circuit television (CCTV) camera for observation coverage.
- C. Stanchion shall have minimum ¼ inch gap at bottom of station from mounted surface to allow air circulation preventing accumulation of moisture inside of stanchion.

3.03 TESTING

A. Testing shall be in conformance with SECTION 27 01 00 OPERATION AND MAINTENANCE OF COMMUNICATIONS SYSTEMS, except as modified herein.

SECTION 27 50 00

COMMUNICATIONS SECURITY/CLOSED CIRCUIT TELEVISION SYSTEM PART 1 – GENERAL

1.01 SUMMARY

A. RTD currently uses the NICE/Qognify Systems AMS security management software platform for the management of their video surveillance system. This platform, along with cameras, workstations and a high-speed IP transport network allows for recording, transmission, viewing, analytics and event management. Cameras are located on existing rail platforms, buildings, passenger tunnels, in parking facilities, at bus drop-off areas, and at gate crossings. The cameras are connected to existing HP IP switches for transport over RTD's IT high speed IP back bone. Recording and management of the video streams is provided by multiple NICE/Qognify NVR/SVR platforms and the required storage located in the wayside communication houses and at the Security Command Center (SCC). In addition, the AMS software provides software-based video switcher function. Using these tools, the cameras are monitored real-time by security technicians and stored for archival purposes. This system allows the SCC and Commuter Rail Maintenance Facility (CRMF) technicians to view all real time or recorded video along RTD's existing LRT system from a single interface.

B. The Security/Closed Circuit Television (S/CCTV) System to be furnished and installed by this Contract is intended to be integrated into the existing system to provide the following functions:

1. Use of IP fixed and PTZ cameras.
2. Surveillance coverage of emergency telephones, stairways, elevators.
3. Real time viewing and video recording of all camera images for incident review and evidence cataloging.

C. This Contract shall provide the procurement, installation and testing of additional IP cameras, cabling, connectors, network switches, network video recorders (NVR/SVR), and software provisioning to integrate into RTD's existing video viewing system.

1.02 RELATED SECTIONS

- A. Contract Terms and Conditions
- B. Division 01 – General Requirements
- C. SECTION 27 02 00 – Communications System Overview
- D. SECTION 27 08 10 – Optical Fiber Testing and Measurements
- E. SECTION 27 17 00 – Testing, Identification and Administration
- F. SECTION 27 35 00 – Communications Emergency Telephone System
- G. SECTION 27 60 00 – Communications Wire, Cable and Raceway

1.03 REFERENCES AND STANDARDS

A. The Contractor shall design, construct, and test the Communications System to the latest revision and applicable sections at the time of Award of Contract of the following codes and standards:

1. National Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual
2. National Electric Safety Code (NESC)
3. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 802.3
 - b. IEEE 802.3at DTE Power Enhancements
 - c. IEEE 802.3u
4. Insulated Cable Engineers Association (ICEA)

5. American Public Transportation Association (APTA)
6. National Television System Committee (NTSC)
7. Motion Pictures Experts Group (MPEG)
8. Electronic Industries Association (EIA)
9. Internet Engineering Task Force (IETF)
10. International Electrotechnical Commission (IEC)
11. American National Standards Institute (ANSI)
 - a. ANSI 60529 Degrees of Protection Provided by Enclosures (IP Code)

1.04 QUALITY ASSURANCE

A. Quality assurance planning, implementation and reporting shall be in conformance the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, except as modified herein.

1.05 SUBMITTALS

A. Submittals shall be in conformance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, except as modified herein.

B. Items required to be submitted by the Contractor for Approval as part of the installation plan include, but are not limited to, the following:

1. Locations and mounting of all cameras
2. Text describing each element of the CCTV system
3. Block and lower level diagrams, intended to show each typical configuration
4. Proposed equipment, identified by manufacturer and model
5. Text describing each element of the CCTV Camera
6. Drawings, including detailed block and lower level diagrams, intended to show each typical configuration, including integration into the existing CCTV System
7. Identification and specification of all internal module-to-module data communications interfaces and all electrical interfaces
 - a. unmanaged switches are unacceptable.
 - b. work with RTD IT for approved interfaces and proper installation.
8. Complete NVR/SVR storage calculations
9. Values for all configurable settings
10. List of all lowest level replaceable units, each with MTBF
11. Bill of materials
12. Table showing each camera, its target, purpose and settings.
14. Wattage calculations of camera POE usage on switch locations not to exceed 50% of switch POE capabilities, unless otherwise approved by RTD IT.

PART 2 – PRODUCTS

2.01 GENERAL

A. The Contractor shall provide a complete and fully functional enterprise-class, IP-based, networkable CCTV system for the Systems Engineering Services that meets the requirements of this Section. All equipment shall be of solid-state design and construction. All software, equipment and materials shall be new and shall be the latest version or model in use at the start of construction and less than one-year-old from manufacture date. Equipment and materials shall be the best of their respective kinds; they shall be free of corrosion, scratches and other such defects. Workstations, network video recorders, cameras, power supplies, storage area networks, IP switches, and software shall be compatible with and incorporated into RTD's existing NICE/Qognify Systems video management system and be approved by RTD IT.

- B. The Contractor shall coordinate the installation of the S/CCTV system with the lighting, architectural and landscaping design to ensure that location and lens, and camera types are appropriate for the application.
- C. The Contractor shall coordinate with RTD's Security to ensure proper positioning of the CCTV cameras covering emergency telephones
- D. The Contractor shall upgrade RTD's existing NICE/Qognify video management system and update the software in the NVR/SVR to the current version in use by RTD prior to commencing with the required Work.
- E. Technicians installing and configuring the NVR/SVR, security management software or the workstations shall be certified to perform that function by NICE/Qognify Systems Inc. and/or shall have previously installed and configured NICE/Qognify systems of similar or more complexity on at least three previous projects. Such certification or work experience shall be provided to the Project Manager and SCC.

2.02 NETWORK VIDEO RECORDERS

A. Network Video Recorders (NVR/SVR) shall be provided in the IT rack in the security room as required. The NVR/SVR shall be based on NICE/Qognify Vision software and have 33 TB or 44 TB (up to 140 TB Max) of internal RAID storage. The Model number shall be Nice/Qognify SVR9420, SVR9620, or SVR9820 or equivalent approved by SCC. The NVR/SVR shall support real-time camera viewing from the SCC of H.264 video at 30 frames per second at full camera resolution and storage at 15 frames per second, full camera resolution for 30 days. By modifying hardware, future provision shall be provided for viewing and recording simultaneously H.264 video at 30 frames per second at full camera resolution.

1. Recorded images shall have a digital signature or hashing method so that the chain of evidence can be preserved. The NVR/SVR shall provide simultaneous recording, viewing and management of a maximum of 64 cameras at 30 frames per second, full resolution viewing and simultaneously 15 frames per second, full resolution recording using H.264 compression.
2. The NVR/SVR shall have a high-speed IP interface, as required to obtain the required remote viewing rate, connectivity for transmission of the video IP-traffic to the Operations Control Center (OCC) and SCC via the Communications Transmission System (CTS). In addition, the NVR/SVR shall be SNMP compatible and configured for management via RTD's existing Network Management System (NMS).
3. The NVR/SVR shall not use any multiplexing or time-division technology for IP video transmission.
4. The NVR/SVR shall be based upon a fully modular architecture, allowing for upgrades for additional recording capacity in the future.
5. The system shall simultaneously display live playback and recorded video while continuously recording video.
6. Recording operation shall not be interrupted or stop for playback or live viewing.
7. The NVR/SVR shall have the ability to capture, digitize and record each camera individually and shall not utilize any multiplexing or time-division technology for video or audio recording.
8. The supported compression formats shall be:
 - a. MPEG4
 - b. MJPEG
 - c. H.264
9. The NVR/SVR shall support the following sources of IP video:
 - a. Fixed IP cameras
 - b. Pan Tilt Zoom (PTZ) IP cameras
10. The NVR/SVR shall support a minimum of two separate network interface cards (NICs).
11. The NVR/SVR shall include support for the following network segments:
 - a. Video collection network –the network in which video is collected, encoded, and transported over IP to the NVR/SVR.
 - b. Video viewing network –the video is transported over IP to remote or local decoding devices which display the video data on analog or digital displays.
12. Network segment assignment options:
 - a. The NVR/SVR shall be configured with different network segment assignments for each of the NICs.
 - b. The NVR/SVR shall be configured with different network segment assignments on the same NIC.
13. The NVR/SVR shall support the following network protocols in the collection network:
 - a. Real Time Protocol (RTP)
 - b. User Datagram Protocol (UDP)
 - c. Transmission Control Protocol (TCP)
 - d. Internet Protocol (IP)
 - e. Hyper Text Transfer Protocol; (HTTP)

- f. Real Time Streaming Protocol (RTSP)
14. The NVR/SVR shall support the following network protocols in the viewing network:
 - a. RTP
 - b. UDP
 - c. TCP
 - d. IP
 15. The NVR/SVR shall support the following networking environments for the NVR/SVR to decoding device connections:
 - a. Local workstation/decoder over LAN where the streaming is done by multicast
 - b. Local workstation/decoder over LAN where the streaming is done by unicast UDP
 - c. Local workstation/decoder over LAN where the streaming is done by unicast TCP
 - d. Remote workstation/decoder over narrowband WAN is done by multicast
 - e. Remote workstation/decoder over narrowband WAN is done by unicast UDP
 - f. Remote workstation/decoder over narrowband WAN is done by unicast TCP
 16. The CCTV System shall be capable of recording and monitoring cameras in different frame rates. Each channel configured in the NVR/SVR shall have an individual setup for the following settings:
 - a. Brightness
 - b. Contrast
 - c. Color
 - d. Sharpness
 - e. Saturation
 - f. Hue
 - g. White balance
 17. The NVR/SVR shall support Axis, Sony, Samsung, and Panasonic IP cameras.
 18. The NVR/SVR shall support video encoders and decoders from at least four vendors from the top ten vendors in terms of domestic sales of video encoders and decoders.
 19. The NVR/SVR shall provide alarms for the connected video storage to the management system in the following conditions:
 - a. Power supply problem
 - b. Fan problem
 - c. Temperature problem
 - d. Redundant Array of Independent Discs (RAID)problem
 - e. Bad disk
 - f. Operating system or other software or configuration problem
 20. The NVR/SVR shall have the below additional functionality:
 - a. Ability for failure of the NVR/SVR to be detected and automatic rerouting of the video images to a remote backup NVR/SVR
 - b. Hot-swappable removable, disc drives
 - c. Time stamp each of the camera images. Timing source shall be by RTD provided NTP source over the high-speed IP network
 - d. Video signal loss detection
 21. The NVR/SVR shall be rated to operate in a seismic zone 1 environment.

2.03 VIDEO STORAGE

- A.** The Contractor shall provide, install and test video storage as required in the security room in the parking facility. The video storage shall be sized to store a minimum of 30 days of H.264 video for all cameras in its area at 15 frames per second, full resolution, plus 20% spare for future expansion. At a minimum, the storage capacity shall be 33TB or larger and approved by SCC.
- B.** The video storage configuration shall use a RAID configuration. No failure of a disc, disc controller, power supply, or computer I/O bus interface shall interrupt recording or cause the video to become unavailable.
- C.** Discs and power supplies shall be hot swappable.
- D.** Commercial-off-the-shelf (COTS) backup/restore equipment, software, and storage media shall be provided for the video storage.
- E.** The video storage shall be rated to operate in a seismic zone 1.

2.04 FIXED CAMERAS

A. For installation within elevator cabs:

1. The elevator camera dome system shall be a vandal resistant, miniature camera dome system with high resolution color IP camera and an enclosure consisting of a back box, lower dome, and mounting. The elevator camera shall be AXIS P3905-R Mk II or equivalent.

B. For all other fixed camera installations:

1. The fixed camera dome system shall be a discreet, miniature camera dome system high resolution color IP camera, and an enclosure consisting of a back box, lower dome, and mounting.

2. All emergency telephones shall be covered by fixed cameras. Cameras shall have sufficient resolution and field of view to provide facial recognition of persons using the equipment. Cameras covering TVMs shall also capture all monetary exchange and human/machine transactions.

3. The fixed camera dome system shall be AXIS Q3515-LVE or equivalent and furnished and installed by the Contractor.

2.05 FOR ALL PAN-TILT-ZOOM (PTZ) CAMERA INSTALLATIONS:

A. The PTZ camera dome system shall be a discreet, camera dome system high resolution color IP camera, and an enclosure consisting of a back box, lower dome, and mounting.

B. The PTZ cameras shall be focused on the incoming or outgoing traffic lanes of the garage as noted on the drawings. Each lane will have a dedicated PTZ camera. There shall also be cameras on one set of lanes going to the surface lot adjacent to the parking garage.

C. The PTZ camera system shall be AXIS Q6055-E or equivalent and furnished and installed by the Contractor.

2.06 BACK BOX AND LOWER DOMES**A.** The back box and lower dome shall meet or exceed the following design and performance specifications:

1. Weather Resistant -IP66 waterproof and dust resistant rated. All cameras mounting hardware used shall be by the camera manufacturer and furnished and installed by the Contractor.

2.07 CAMERA POWER DISTRIBUTION

A. The camera power shall be supplied by the Power Over Ethernet (POE) output on the network switches or with an approved POE injector.

1. If a high POE output is required then a POE Injector, AXIS POE injector model T8134 Midspan or equivalent shall be furnished and installed by the contractor.

2. Wattage calculations of camera POE usage on switch locations not to exceed 50% of switch POE capabilities, unless otherwise approved by RTD IT.

2.08 LIGHTNING PROTECTION

A. Lightning protection shall be provided for all copper signal, power and control circuits entering a Communications enclosure, room and case from an external location. An external location is defined as external or outside the parking garage building.

B. Shielded Twisted Pair (UTP) lightning protection

1. Minimum requirements for UTP lightning protection include:

a. Maximum operating voltage of 7.5 Volts

b. Maximum insertion loss 1 dB

c. Maximum surge current (8 x 20 microseconds) 500 Amps total

d. Maximum surge voltage (1.2 x 50 microseconds) 6000 Volts

e. Clamping voltage 7.5 Volts

f. Clamping response time less than 5 nanoseconds

g. Current non load bearing

h. Pass voltage tested to ANSI/IEEE B3 impulse less than 15 Volts peak

i. Power dissipations (8 x 20 microseconds) 100,000 Volt-Amps

C. Twisted pair data lightning protection

1. Minimum requirements for data lightning protection include:

- a. ROHS compliant
- b. Protection of all power circuits and communications links
- c. Impact and weather resistant

PART 3 –EXECUTION

3.01 INSTALLATION COORDINATION

A. The Contractor shall submit for review and Approval, in accordance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, locations and mounting of all cameras.

1. Camera locations can be moved prior to installation as per SCC instruction within 10 feet of original location with no extra cost to RTD
2. Work with SCC on final location and direction of camera view.

B. The Contractor shall interface with the Project Manager to determine the function of each camera to be installed on the system. Each camera's function shall be categorized as either to detect, monitor, identify or recognize the target. Based on the function of the camera, the Contractor shall determine the percent of the screen to be occupied by the target. The Contractor shall use APTA-IT-CCTV-RP-001-11 for reference, with addendum March 2014. This percentage shall be the below based on the function of the camera:

1. Detect –Not less than 50% of the screen occupied by the target
2. Monitor –Not less than 10% of the screen occupied by the target
3. Recognize –Not less than 50% of the screen occupied by the target
4. Identify –Not less than 120% of the screen occupied by the target

C. The Contractor shall capture this camera target information in a table that lists the camera location, target, function, field of view, and resolution requirement.

D. Once the Project Manager comments have been addressed and the location, field of view, and lens setting for each of the cameras have been established, it shall not be revised without a submittal and Approval of the Project Manager.

3.02 INSTALLATION

A. The Contractor shall furnish licenses for RTD's existing Nice/Qognify system sufficient to support all CCTV cameras required by this Work.

1. Licenses will be installed in the existing Nice/Qognify system by SCC.

B. The Contractor shall be responsible for proper placement of all equipment to ensure required operating clearances around all equipment. Further, the equipment location shall take in consideration maintenance access and safety to maintenance and operations personnel and SCC has final say on all locations.

C. In all cases the Contractor shall locate the S/CCTV equipment to ensure proper operation of the equipment. Signal and power distance calculations for equipment shall be included in the design review process and consult with RTD IT.

D. The Contractor shall install cameras to capture the designated areas specified by RTD. The camera views should provide adequate coverage and not be blocked by columns, trees, or structures. Final adjustment of the field of views of the cameras shall be an interactive process between the Contractor and RTD after all cameras have been mounted and tested.

E. As shown on the Contract Drawings, cameras are mounted on light poles, ceilings or walls. The Contractor shall install the cameras to ensure that Contractor supplied mounting provisions are adequate and matches the architectural treatment of the pole, ceiling, or wall. All mounting hardware to be Approved by the Project Manager. Mounting hardware shall be primed and painted to match the color scheme of the shelter or pole it is mounted on

3.03 TESTING

A. Testing shall be in conformance with SECTION 27 17 00 TESTING, IDENTIFICATION AND ADMINISTRATION, except as modified herein.

PART 4 -MEASUREMENT AND PAYMENT

Work in this Section shall not be measured or paid for separately, but shall be considered incidental to all Work under this Contract

SECTION 27 51 00

COMMUNICATIONS ACCESS CONTROL SYSTEM

PART 1 -GENERAL

1.01 SUMMARY

A. The Contractor shall extend RTD's existing Access Control System to remotely monitor and control access to the doors and locks as required by the Work Orders of this Project.

1. The Access Control system shall integrate into RTD's existing Access Control System, but the system shall be capable of stand-alone operation (via the Intelligent System Controller and the remote reader interface modules) in the event that communication to the existing head end system is lost. The doors shall receive door securing devices including a door sensor, a proximity card reader, an electronic strike, and a passive infrared (IR) request to exit (REX) mechanism.

2. The new access control subsystem will integrate into RTD's existing access control architecture. The access control controllers will communicate with the Security Command Center (SCC) access control servers.

3. The installer will be required to be Lenel certified on the Lenel Access Control products to be provided as a part of this Contract. This certification shall be provided to the Project Manager on request.

4. The SCC access control software will be modified by RTD. The Contractor shall furnish additional licenses for the required doors.

1.02 RELATED SECTIONS

A. Contract Terms and Conditions

B. Division 01 –General Requirements

C. SECTION 27 05 28 – PATHWAYS FOR COMMUNICATIONS SYSTEMS

D. SECTION 27 08 10 – OPTICAL FIBER TESTING AND MEASUREMENTS

E. SECTION 27 17 00 - TESTING, IDENTIFICATION AND ADMINISTRATION

1.03 REFERENCES AND STANDARDS

A. The Contractor shall adhere to the latest revision of the following standards:

1. Americans with Disabilities Act (ADA) of 1990

2. ADA Accessibility Guidelines (ADAAG)

3. National Electric Code (NEC) -NFPA 70

1.04 QUALITY ASSURANCE

A. Quality assurance planning, implementation and reporting shall be in conformance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, except as modified herein.

1.05 SUBMITTALS

A. Submittals shall be in conformance with the CONTRACT TERMS AND CONDITIONS and DIVISION 01 GENERAL REQUIREMENTS, except as modified herein.

PART 2 - PRODUCTS

2.01 NETWORK ACCESS CONTROL SYSTEM

A. All of the Access Control rooms, doors, and locks in the Access Control system shall integrate into RTD's existing LENEL Access Control System, but the system shall be capable of stand-alone operation (via the Intelligent System Controller and the remote reader interface modules) in the event that communication to the existing head-end system is lost.

B. The Contractor shall coordinate the mounting and installation of the remote access control panel locations with the RTD Project Manager. Remote access control panels shall be installed in a secure location (not on the public side of a door) and shall be easily accessible by RTD security personnel.

C. The Contractor shall furnish and install the following, or approved equal, necessary equipment and all ancillary equipment to complete the access control system:

1. Card Reader: HID Thinline II –5395CG100
2. HES 1006 Electrified Strike with faceplate
3. Sentrol 2507AH-L door sensor, or Sentrol 1078c Concealed door sensor with wire leads-¾ inch
4. Bosch DS160 PIR request to exit device
5. Intelligent System Controllers-Lenel LNL-2220, LNL-1300, and LNL-1320
6. Power Supply–Altronix LNL-AL600UL3X
7. LENEL OnGuard licensing for RTD's existing Lenel OnGuard servers.

D. All Equipment and locking devices not previously used in previous projects must be approved by the project manager and **SCC** personnel.

E. The Contractor shall detail the Access Control operational requirements of each door as a part of the Contractor's design. The Contractor shall adjust the door-securing devices of each access controlled door according to the operation requirements for that door.

F. Door status sensors, electronic strikes, and electrified locking mechanisms shall be embedded into the door frame for rigid, secure, low profile operation.

G. Card readers shall be installed on the public side of access-controlled doors and cabinets and be accessible according to ADA standards and guidelines.

PART 3 -EXECUTION

3.01 GENERAL

A. The Access Control system shall integrate into RTD's existing Access Control System, but the system shall be capable of stand-alone operation (via the Intelligent System Controller and the remote reader interface modules) in the event that communication to the existing head-end system is lost.

B. The Contractor shall coordinate the mounting and installation of remote access control panel location in the security room with the Project Manager. Remote access control panels shall be installed in a secure location (not on the public side of a door) and shall be easily accessible by RTD security personnel.

C. The Contractor shall detail the Access Control operational requirements of each door as a part of the Contractor's installation plan. The Contractor shall adjust the door-securing devices of the access-controlled doors according to the operation requirements for that door.

D. Door status sensors, electronic strikes, and electrified locking mechanisms shall be embedded into the door frame for rigid, secure, low profile operation.

E. Card readers shall be installed on the public side of access-controlled doors and be accessible according to ADA standards and guidelines.

F. The access control system shall be installed, and the equipment shall be installed properly for a fully functional access control system. The controller and power supply shall be mounted in the security room on the first level and in the third floor Electrical Room in the approved area.

3.2 TESTING

A. Testing shall be in conformance with SECTION 27 08 10; OPTICAL FIBER TESTING AND MEASUREMENTS, and Section 27 17 00; TESTING, IDENTIFICATION AND ADMINISTRATION, except as modified herein.

PART 4 - MEASUREMENT AND PAYMENT

Work in this Section shall not be measured or paid for separately but shall be considered incidental to all Work under this Contract.