

**SECTION 26 0100****OPERATION AND MAINTENANCE OF ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Closeout
  - 1. Operation and Maintenance Manual: For equipment and systems to include in operation and maintenance manuals.
- B. Shop Drawings
  - 1. As-Built Drawings: For recording installed conditions that deviate from design documents.

**1.2 OPERATION AND MAINTENANCE MANUAL**

- A. The contents of operating and maintenance manual shall include the following:
  - 1. Project Information Cover: Title of Project; Name and address of Owner, Design Professionals, Contractor of Record and Subcontractor; System name and specification references.
  - 2. Index: Contents of the manual.
  - 3. Warranty Statements: Furnish a warranty statement for each system, reiterating the terms of warranty identified within the Contract Documents, and identifying how the Owner is to obtain warranty service. Clearly identify which products are covered by Manufacturer warranties beyond the Contractor required minimum warranty period. The term of manufacturer warranty shall also be identified (e.g., 1-year parts and labor). Identify the date that the warranty for the system starts. This date shall be the date listed on the Certificate of Substantial Completion (if one was issued to the contractor specifically for the system) or the date listed on the Notice of Final Completion. Supply standard out-of-warranty service rates and service contact information.
  - 4. Bill of Materials: List of products supplied, and serial numbers of each product.
  - 5. Product Datasheets and Shop Drawings: Manufacturer datasheets and shop drawings for each product and system supplied.
  - 6. Manufacturer Owner / User Manuals: Manufacturer's Owner's or User's manual for each product, and Manufacturer's Installation instructions and other documentation supplied with the product.
  - 7. Extra Material Schedule:
    - a. Complete spare parts schedule for components of equipment furnished, which are not factory generic information, but accurate for the equipment provided.
    - b. Itemized list of each piece of electrical, architectural and Owner equipment having electrical connections with circuit and panelboard locations; also, list related expendable equipment required for each item, such as fuse size and type, pilot lights, catalog numbers of fuses, overloads, etc. as applicable.
    - c. Itemized list of each luminaire type with catalog number of replacement lamps, ballasts, boards, drivers, trims, lenses, accessories, etc.
  - 8. Maintenance Procedures: Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; testing, aligning and adjusting instructions.

9. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
10. Function and Operating Descriptions: Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
11. Operating Procedures: Manufacturer's printed operating procedures including start-up, break-in, normal operating instructions, regulation, control, stopping, shutdown, and emergency instructions.
12. Include Product Certificates, Source quality-control test reports and Field Quality-Control Reports
13. Test Reports and Checklists: Test reports, checklists, and other forms generated and completed for the Project.
14. Training Information: Copy of training outlines/agendas, training session handouts, training sign-in sheets, and signed delivery receipt for each training session recording; Separate USB drive, labeled, for audio/video-recorded instructions to Owner, for operations and maintenance for each system.
15. As-Built Drawings.

### **1.3 AS-BUILT DRAWINGS**

- A. Obtain two complete sets of electrical prints and use them to provide progress record drawings which are separate, clean, prints reserved for the purpose of showing a complete picture of the work as actually installed (including routing of conduit and cables). These drawings also serve as work progress report sheets. Make notations, neat and legible thereon daily as work proceeds. Make these drawings available for inspection at all times and keep them at the job at a location designated by the Owner's Representative.
- B. Maintain the clean, undamaged set of prints of drawings as well as a set of submittal drawings and coordination drawings. Mark the sets to show the actual installation where the installation varies from the Documents as originally shown. Include locations of underground and concealed items if placed other than shown on the Documents. Where shop drawings are used, record a cross-reference at the corresponding location on the Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
- C. Show changes in: size, type, capacity, etc., of material, device or piece of equipment, location of device or piece of equipment; location of outlet or source of building service systems; routing of piping, conduit, or other building services. Record location of concealed equipment, electrical service work, conduits and other piping/work by indication of measured dimensions to each line from readily identifiable and accessible walls, column lines or corners of building. Indicate approved substitutions, modifications, and actual equipment and materials installed.
- D. Affix near the titleblock on each drawing the Contractor's Company Name(s), signature of Contractor's Representative(s) and current date.

**PART 2 - PRODUCTS (NOT USED)****PART 3 - EXECUTION****3.1 INSTRUCTION OF THE OWNER'S PERSONNEL**

- A. Provide instruction in the proper operation and maintenance of equipment that requires routine servicing. Include the following:
  - 1. Review of operation and maintenance manuals.
  - 2. Required tools.
  - 3. Lubricants.
  - 4. Extra Materials.
  - 5. Cleaning.
  - 6. Hazards.
  - 7. Warranties and maintenance agreements.
  
- B. Demonstrate equipment and systems operation including the following:
  - 1. Start-up.
  - 2. Shut-down.
  - 3. Emergency conditions.
  - 4. Safety procedures.
  - 5. Setpoint and schedule adjustments.
  - 6. Economy and efficiency adjustments.

**END OF SECTION 26 0100**

**SECTION 26 0501****COMMON WORK RESULTS FOR ELECTRIC****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to all sections.
- B. Obtain the latest Northern Kentucky University Design and Construction Standards document(s) from the Owner. Comply with all Owner-specific requirements in addition to requirements set forth in these specifications and accompanying drawings. Should there be a conflict, the Owner's standards shall take precedence, unless prevailing codes and regulations mandate otherwise.

**1.2 GENERAL DIRECTION**

- A. Submittal of a bid indicates that the contractor has examined the drawings, specifications, and had an opportunity to visit the site to be able to provide a comprehensive complete bid.
- B. The intent of these specifications and the accompanying drawings is to provide complete and workable systems as shown, specified and required by applicable codes. Interpret these specifications in conjunction with the drawings and provide all work described. If work is shown on drawings and not mentioned in the specifications, or vice versa, it is to be included in the work the same as though clearly set forth by both. Should there be a conflict between the specifications and drawings, provide the greater quantity or better quality. Immediately notify owner's representative and design professional of such conflicts.
- C. The drawings that accompany these specifications are diagrammatic and although size and location of equipment is drawn to scale wherever possible make use of submittal data and verify all dimensions on site. They do not show every conduit, offset or pull / junction box which may be required to install work in the space provided and avoid conflicts. The drawings are an outline to indicate the approximate location and arrangement of work. Follow the drawings as closely as is practical and install additional pull / junction boxes and offsets where required by site conditions and codes at no additional cost. Install all new work in such manner as to conform to the structure, avoid obstructions, provide required service clearances and preserve headroom. Do not scale from drawings, all measurements should be taken in the field.
- D. Coordinate all new work with all other contractors and installers in addition to existing building obstructions and install accordingly. Refer to coordination drawings of other trades. Comply with requirements of architectural drawings including but not limited to mounting height and locations.
- E. Provide all labor and material, tools and equipment necessary to render all systems complete and operational, and ready for turnover to Owner. Work defined within this section applies for all Division 26 work, including work of Division 26 that is provided in support of work of other

divisions. Unless specifically indicated otherwise in documents of other construction divisions, products to be installed shall also be furnished under Division 26.

- F. Fully research peculiarities and limitations of space available for installation of work with materials being provided. Work around material lead times to not extend project schedule.
- G. Branch circuiting shown on drawings is also diagrammatic not intended to be the installation location. For instance, circuiting shown on the exterior of the building connecting building mounted items shall be installed indoors concealed wherever possible. For circuits remote from the building, provide the work below grade unless otherwise indicated.
- H. Complete work, or part(s) thereof, at times as may be designated by the Owner's Representative, so that it can be used for temporary or permanent use. Do not construe such use of the system as an acceptance of it by Owner.
- I. During mobilization or construction, if an abnormal condition is uncovered either with existing conditions, equipment loads, submittal data, etc. bring these to the attention of the Design Professional for review.
- J. Owner's Representative or Design Professional may relocate fixtures, devices, equipment, etc. prior to installation within a 20-foot limit at no additional charge.

### **1.3 GENERAL STANDARDS**

- A. Provide work in compliance with applicable provisions of the following standards. Provide listing and labeling for all electrical materials, marked for respective intended uses, from UL or other Nationally Recognized Testing Laboratory (NRTL) that is acceptable to applicable Authorities Having Jurisdiction (AHJs).
- B. Provide materials, installation methods, workmanship, testing, etc., in strict accordance with the latest adopted edition of applicable standards and adopted codes, including (but not limited to) the following.
  - 1. International Building Code
  - 2. State Building Code and applicable amendments
  - 3. State Energy Code
  - 4. Utility company requirements and standards as applicable
  - 5. All provisions and requirements of NFPA (National Fire Protection Association)
  - 6. National Electrical Code (NEC), NFPA 70
  - 7. Life Safety Code, NFPA 101
  - 8. Local governmental and other prevailing codes and ordinances
  - 9. ADA/ADAAG requirements (American with Disabilities Act) including all applicable Standards for Accessible Design.
  - 10. UL (Underwriters Laboratories Inc.)
  - 11. ETL (Intertek Testing Services NA, Inc.)
  - 12. CSA (CSA Group Testing and Certification Inc.)
  - 13. FM (Factory Mutual Insurance Company)
  - 14. ASME (American Society of Mechanical Engineers)
  - 15. NEMA (National Electrical Manufacturers Association).
  - 16. NECA (National Electrical Contractors Association)
  - 17. IP (International Protection Rating / Ingress Protection Rating)

**1.4 PERMITS AND REGULATIONS**

- A. Obtain and pay for permits, fees, certificates of inspection and approval, etc. required for this branch of the work. Furnish Owner with certificates of final inspection and approval prior to final acceptance of this branch of the work.
- B. Laws and regulations which bear upon or affect the various branches of this work shall be complied with by this contractor and are hereby made a part of this contract.

**1.5 DEFINITIONS**

- A. Furnish - Procure, supply and deliver to project site, ready for installation, install and warrant (unless indicated otherwise on documents). Include warranty expenses.
- B. Install - Assemble, wire and connect loose-shipped components on site. Place in position for service or use, including material, labor, accessories, services, and testing. Wire, connect, and render fully operational for intended use.
- C. Provide - Furnish and Install. Similar Terms: "include", "shall", "equip with", "consisting of"
- D. Equal or Equivalent - Determination of equivalency to be made by design professional for all products not listed as basis-of-design.
- E. Substantial Completion - Where frontend documentation does not define, products and systems must be fully installed as designed, tested, adjusted, labeled, and functionally demonstrated to owner.
- F. NRTL: Nationally Recognized Testing Laboratory
- G. OCPD: Overcurrent protective device.
- H. SCCR: Short-circuit current rating.

**1.6 REQUESTS FOR INFORMATION**

- A. Submit all questions, requests for information (RFIs) and similar queries through the formally-established RFI process for the project that has been accepted by the Owner's Representative, Design Professionals, Prime Contractor and subcontractors. Submit as a PDF file. Do not submit as text in an email.

**1.7 AVAILABILITY OF ELECTRONIC DRAWINGS**

- A. If expressly permitted by the Owner and the terms of the Contract, editable electronic drawings may be made available for the creation of shop and as-built drawings upon request. Drawings will be made available at the discretion of the Engineer.

- B. "Request Drawings" form can be accessed, filled out and submitted at <http://www.klhengrs.com> (right hand side of page - Contractor Resources). Direct access to this form can be found here: <http://files.klhengrs.com/requestdrawings.html>

## **1.8 QUALITY ASSURANCE**

- A. Contractor shall have a minimum five (5) years experience in the installation of systems similar to the systems specified. Contractor if requested shall demonstrate his ability to perform all work to be included under the contract. Assurance if requested, shall be in the form of a list of past projects of similar size and complexity and a list of six (6) references pertaining to those projects. Failure to demonstrate these quality assurances shall be taken as a statement of the contractor's inability to perform.
- B. Contactor and all workers trained in electrical safety as required by NFPA 70E.

## **1.9 WARRANTY / GUARANTEE**

- A. Provide a warranty/guarantee in written form as part of O&M manual stating that all work, materials, equipment and parts are warranted to be free of defect for a minimum period of one year from the date of Substantial Completion. Warranty period and requirements may be expanded in drawings or subsequent specification sections. Repair or replace (owner's option) any defects or failures at no cost to the owner within the warranty period. Issues arising within warranty period must be attended to in a timely manner and in no case exceed four (4) working days. State this in writing as part of O&M manual. Replace defective items to the satisfaction of the Owner's Representative and the Design Professional.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS AND EQUIPMENT**

- A. Provide materials that are new, full weight, of the best quality. Provide similar materials that are of the same type and manufacturer. Provide materials, apparatus and equipment with NRTL listing and label where regularly supplied. Provide only products that are intended for, rated for and suitable for the installed condition.
- B. Provide basis of design products or listed products equivalent in quality, performance, aesthetics, and product support (factory and local) to that specified as basis of design. Products not basis of design are subject to review by the Design Professional and possible rejection. Listing of a product manufacturer by name alone as an equivalent manufacturer shall not equate all products offered by that manufacturer to the basis of design.
- C. Bear all costs incurred from deviation from basis-of-design materials, methods, labor, services, etc. Use of materials, methods, labor, services, etc. that deviate from the basis-of-design will be considered a statement that capacities, requirements, clearances, arrangements, performance, etc. have been checked, verified, found satisfactory, and align with intent of specified work and applicable codes and regulations.

- D. Should deviation from basis of design equipment impact other contractors scope of work it shall be the responsibility of this contractor to coordinate with and cover these costs in addition to their own.

### **PART 3 - EXECUTION**

#### **3.1 GENERAL DIRECTION**

- A. Unless specifically indicated, provide all specified and drawn work as required to render all equipment and systems fully operational, including all ancillary, accessory, and support work.
- B. Install equipment and materials in strict accordance with manufacturer's written instructions. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values.
- C. In cases where products / materials are furnished by Owner or others, provide the following services: receive, transport and securely store materials on site; remove materials and components from packaging; assemble all materials and components per factory instructions; install, wire and connect materials and components as recommended by manufacturer for a fully operational installation.
- D. Wire and connect electrical equipment furnished under this branch of work, other branches of work and by the Owner. Review documents of other trades to identify electrically operated/controlled equipment that is furnished or installed by the Owner, or by other trades. Provide power connections and local disconnects for same. Provide control wiring (including relays, starters, programming, etc.), as required to render equipment fully operable.
- E. Except where otherwise indicated, provide fully-rated or series-rated overcurrent protection (OCP). Provide equipment and OCP rated to meet or exceed the calculated available series-rated fault current at the respective node in the power distribution system. Series-rated breakers/systems are not permitted where prohibited by prevailing codes and standards, including applications involving motor contribution as addressed in Article 240.86(C) of NFPA 70.
- F. Remove and replace items that may impede new work installation including but not limited to fencing, doors, gypsum, lift-out panels, and structures to provide pathway for moving equipment into place.
- G. Examine surfaces to receive products for suitable mounting conditions and verify compliance with installation tolerances and other conditions affecting performance of the work. Proceed with installation only after unsatisfactory conditions have been corrected.
- H. Drawings indicate dimensions for typical equipment configurations including clearances between equipment and adjacent surfaces and other items. Ensure selected products and equals comply with layout provided and required clearances.



**3.2 SUPERVISION AND WORKMANSHIP**

- A. Workmanship throughout shall conform to the standards of best practice and all labor employed must be competent and qualified to do all the work required.
- B. Furnish the services of an experienced superintendent to be in constant charge of the work at all times.
- C. Provisions shall be made for owner's representative or design professional to make rough-in and open ceiling inspections prior to covering up work.

**3.3 CHANGE OF WORK**

- A. In the event of revised scope or work formally issued through Change of Work order, contractor shall provide an itemized breakdown of pricing and receive approval prior to commencing with work.

**3.4 COORDINATION**

- A. Commence with coordination in a timely manner. Subsequent additional compensation, special allowances, additional construction time, etc. will not result from failure to coordinate (including providing related information to other trades for review) in a timely manner. Do not plan, fabricate or install work before consulting with and properly coordinating with other trades so that work will not interfere with that of other trades.
- B. Coordinate layout and installation of equipment and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.
- C. Participate in multi-trade coordination efforts prior to commencing with material procurement or installations. Provide electrical coordination drawings, and participate in preparation of coordination drawings by other trades, prior to fabrication or installation of equipment, materials, etc. Coordinate actual clearances of installed equipment. Coordinate exact location of electrical outlets, lighting fixtures, conduits, raceways, equipment, cable assemblies, applicable devices, etc. well in advance of installation so there will be no interferences at installation between the various trades.
- D. Ensure that required workspace clearances, required clearances for access and maintenance and electrical working clearances of all devices and equipment complies with NEC (NFPA 70) Article 110. This also applies to finalizing locations of disconnects, starters, contactors and other electrically operated equipment that may require testing or maintenance while energized. Layout all affected equipment on paper, and meet with electrical inspector on-site as needed, prior to ordering related materials or commencing with installations, to ensure compliance with NEC Article 110.
- E. Coordinate and correct conflicts in equipment and materials prior to installation. If a conflict cannot be resolved, refer the matter to the Owner's Representative for a final decision as to method and material.

**3.5 ARCHITECTURAL COORDINATION ITEMS**

- A. Cutting and Patching:
1. Hold cutting and patching to a minimum by arranging with other trades for sleeves and openings before construction is started.
  2. Cut and drill all openings in roofs, walls, and floors required to perform the work. Neatly patch all openings cut. Hold cutting and patching to a minimum by arranging with other contractors for all sleeves and openings before construction is started. When drilling / cutting concrete slabs, utilize ground penetrating radar (GPR) and/or X-ray scanning equipment to verify the location is free from obstruction, including but not limited to: structural rebar / strands / tendons and electrical conduit / wiring. Repair all damage to structural elements that may occur. Provide temporary partitions, dust barriers, vacuums to keep all dust to a minimum. Allow inspection by owner's rep and inspection by authority having jurisdiction prior to concealing any work or uncover and restore work to allow for observation.
- B. Fire Caulking:
1. Fire stopping requirements/locations are not indicated on electrical drawings. Review architectural and other drawings to determine where there will be fire/smoke rated walls, floors, membranes, etc. and rating requirements of same. Provide required fire stopping work associated with electrically related penetrations. Patching through fire rated walls and enclosures shall not diminish the rating of wall or enclosure. Patch shall be equal to rockwool, firestop, caulk or approved "rated" patch / sealant / pillow / grommet / compound / etc. Clean affected surfaces, joints, etc. immediately before applying fire stopping and only apply under recommended temperature and humidity. Apply primer as required by manufacturer. Properly tool sealants for clean look. Subject to compliance with requirements, provide products by one of the following:
    - a. Fire Stop Pillows: Nelson PLW, STI, Hilti, 3M
    - b. Fire Stop Putty: Nelson FSP, STI, Hilti, 3M
    - c. Latex Intumescent Sealant: Nelson LBS3, STI, Hilti, 3M
    - d. Outlet boxes: Nelson FSP, STI, Hilti, 3M
- C. Access Panels:
1. Provide all access panels required for proper servicing of equipment or access to junction boxes as a last resort after first searching out locations for equipment and junction boxes in accessible areas. All access panel locations and sizes must be coordinated with and approved by design team and owner's representative. Provide fire rated and smoke rated access panels where required. Provide frame as required for finish. Coordinate installation with General Contractor as they may elect to install access panel. Exact location(s) must be approved by the Architect. Minimum size to be 12" x 12" for junction boxes and 22" x 22" for equipment, units to be 16-gauge steel, primed for paint, door opens beyond 90 degrees and locking device shall be screwdriver cam locks.
  2. For equipment or junction boxes above gypsum board or "hard ceilings", provide equipment access panels sized to permit complete holistic removal of the unit in its entirety. Access panel shall also be sized to accommodate removal of the largest piece of equipment in the case where such access panel is used as a removal pathway for multiple pieces of equipment. Subject to compliance with requirements, provide products by one of the following:
    - a. Bar-Co., Inc.
    - b. J.L. Industries.
    - c. Karp Associates, Inc.
    - d. Milcor Div. Inryco, Inc.
    - e. Nystrom, Inc.

**D. Conduit Sleeves:**

1. Aboveground, exterior wall penetrations: rigid steel pipe sleeve.
2. Below grade, exterior wall and floor penetrations: schedule 40 cast iron pipe sleeve
3. PVC Pipe Sleeves where allowed: ASTM D 1785, Gray, Schedule 40.
4. Rectangular opening sleeves: Galvanized Sheet Steel, thickness min 0.1 inches.
5. Sleeve Seal Systems: Provide modular sealing device designed for field assembly, EPDM, Nitrile or Silicone based on installation environment with stainless steel bolts and polymer pressure plates. Install type and number recommended by manufacturer for a water tight seal. Provide by one of the following:
  - a. Advance Products & Systems, Inc.
  - b. CALPICO, Inc.
  - c. Metraflex Company (The).
  - d. Pipeline Seal and Insulator, Inc.
  - e. Proco Products, Inc.
  - f. OZ/Gedney
  - g. Link-Seal
6. Sleeve Seal Fittings: Provide manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Install in wall or slab as constructed and grout area around fitting. Provide by one of the following:
  - a. Presealed Systems
  - b. Bio FireShield
  - c. MetaCaulk
7. Sleeves shall be cut flush with both faces of wall. Deburr all sleeves. Floor sleeves shall extend one inch above floor top elevation. Maintain all fire ratings. Use joint compound for around gypsum sleeves. Roof penetrations shall be with flexible boot-type flashing unit or within a pipe curb assembly equal to Pate Co. Curb and flashing per roofing manufacturer's requirements to maintain warranty.

**E. Grout:**

1. Provide non-shrink grout, recommended for sealing openings in non-fire-rated walls or floors, ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout. Provide 5000-psi strength design mix, premixed and factory packaged.

**F. Silicone Sealants:**

1. Provide single-component, silicone-based, neutral-curing elastomeric sealant for exterior work. Provide pourable (self-leveling) grade formulation for openings in non-fire rated floors and other horizontal surfaces. Install only in temperature and humidity as recommended by manufacturer. Colors of all visible sealants to be clear or color approved by owner's rep or design team.

**G. Acrylic Sealants:**

1. Provide one-part, non-sag, mildew-resistant, paintable recommended for exposed applications of interior and protected exterior locations

**3.6 PROTECTION OF SURFACES**

- A.** Make every effort to protect roofs, walls and floors from foot traffic, equipment, carts, lifts, etc. Make roof penetrations and install insulated roof curbs and flashing in accordance with roofing manufacturer's recommendations. Obtain written certification from roofing manufacturer that work has been performed properly and that roof warranty is intact.

**3.7 UTILITY VERIFICATION REQUIREMENTS**

- A. Field verify locations of underground and aboveground utilities, or those otherwise obscured from view, in the vicinity of work prior to commencing work. Utilize "811" call before you dig and hire locating service to identify, locate and mark remaining utilities and private lines. Obtain on-site approval from local utility prior to connecting services. Failure to perform the above shall result in contractor proceeding at their risk and accepting full responsibility for incorrect connections.

**3.8 DELIVERY, STORAGE, HANDLING, AND PROTECTION**

- A. Receive, inspect, store and protect all materials required for new work. Do not accept or install any product damaged in any way.
- B. Comply with all manufacturer guidelines and requirements for movement, storage, and protection of new work. All new work must be stored in a clean, dry place protected from weather and construction traffic. Maintain acceptable temperature and humidity per manufacturer recommendations. When stored inside or during transport through building, do not exceed structural capacity of the floor.
- C. Coordinate and account for sizes of all new work included shipping materials with available openings. Account for rigging of all new work as required and as intended by manufacturer.
- D. Do not install work until work area is sufficiently weathertight, all wet work in area is complete and all work above is complete. Provide temporary heating, cooling or humidity control to maintain acceptable conditions for install per manufacturer recommendations until permanent equipment operational.
- E. Prior to installation, all products shall have the ability to be returned to the supplier or manufacturer after purchase and charged a reasonable restocking fee equal to a small portion of the cost.
- F. Protect all new work through construction from damage. Take safeguards necessary to protect from damage. Items damaged during construction will not be accepted and shall be replaced with new.
- G. Remove and replace all materials that have been installed improperly, physically damaged, moisture or water damaged, or mold damaged.
- H. Fully remove all packaging materials inside and out prior to startup.

**3.9 INTERRUPTION OF SERVICES**

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others without notification to Owner's Representative and written permission. Arrange for and provide temporary electric service meeting requirements of owner. Notify Owner's Representative no fewer than fourteen days in advance of proposed interruption of electric service.

**3.10 STARTUP, TESTING AND ADJUSTMENTS**

- A. Engage a factory-authorized service representative to perform startup service. Perform tests and inspections and prepare reports for submission. Take corrective action for all non-conforming tests.
- B. Prior to energizing, test wires and cables for proper phase to phase connections, electrical continuity and short-circuits. Properly reference and resistance test grounding electrode and equipment grounding conductors. Test service voltage and configuration and take corrective action if necessary. Verify circuit voltage at source prior to energizing any feeder or branch circuit. Energize circuitry and demonstrate capability and compliance with requirements. Ensure the direction of rotation of each motor. Adjust controls, remote monitoring, safeties, operations, moving parts, etc. as applicable. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Complete installation and startup checks according to manufacturer's written instructions.
- C. Set and document final settings of field-adjustable circuit-breaker overcurrent trip values.

**3.11 CLEANING EQUIPMENT AND PREMISES**

- A. Vacuum, clean and wipe down all new work and equipment inside and out. Exposed parts which are to be painted shall be cleaned of all foreign objects and prepped for paint.
- B. During the progress of work, clean up and leave the premises and portions of the building in which work has occurred in a clean and safe condition. Provide this cleaning on a per-shift basis.

**3.12 DEMONSTRATION / TRAINING**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment. Refer to product specific specification for training types and duration.

**3.13 PROGRAMMABLE AND SOFTWARE OPERATED EQUIPMENT**

- A. This subsection applies for systems that incorporate microprocessor based equipment and components. The systems themselves are specified elsewhere within Project Manual.
  - 1. Program software and equipment specifically for phased turnover of spaces based on construction phases. Program, check, and test each system using respective certified factory technician.
  - 2. Room names and numbers may change from architectural drawing names and numbers to actual operational room names and numbers. Contact Design Professionals and Owner to determine actual operating room names, room numbers, etc. and program using actual operational information. Provide interim and permanent programming and configuration work as required to render and maintain systems in full operation.
  - 3. Provide and adapt as necessary the latest release of system software and provide upgrade(s) at final close-out of project.

4. All programming shall be commented in detail and turned over to owner in hard copy printed form and in electronic form on USB drive. This information shall be provided with Operations & Maintenance Manual submission.
5. Existing Systems: Become familiar with existing characteristics, devices, equipment, cabling, configuration, components and programming of affected systems so that expansions, extensions, and retrofits are fully compatible with the existing conditions. Verify that systems are in proper working order prior to beginning work on an existing system. If not, bring defects to the attention of the Owner's Representative. If no notification occurs, it is assumed that the system was in working order. Provide remedial work for subsequent system problems that occur, if any.

**END OF SECTION 26 0501**

**SECTION 26 0502****COMMON ELECTRIC MATERIALS AND METHODS****PART 1 - GENERAL****1.1 GENERAL**

- A. Mounting Heights: Outlet mounting heights as indicated on the plans are approximate. Determine the exact mounting heights (and locations) of outlets in the field with relation to architectural detail and equipment being served. Coordinate outlet location with equipment, with furniture plans and with architectural elevation plans. Where mounting heights are not detailed or dimensioned, contact the Owner's Representative for direction. Prior to rough-in, coordinate final mounting heights of system outlet boxes in field with Owner's Representative. Install boxes at heights as follows, to center of box, unless directed otherwise in field or otherwise noted on E-series drawings or architectural plans. In cases where using center of box for measurement would result in a switch-height device having an operable component higher than 48 inches above finished floor, install boxes lower as needed so that uppermost part of operable component is no higher than 48 inches. Height of boxes dimensioned from ceiling apply to rooms having ceilings 9' or less; in rooms having higher ceilings, locate these as directed in the field.
1. Occupancy Sensors: As recommended by manufacturer
  2. Receptacles: 18"
  3. Wall Mounted Luminaires: As noted on plans or directed by Design Prof.
  4. Control Stations: 46"
  5. Communication Outlets: 18"
  6. Other Outlets/Fixtures/Equipment: As directed by Design Professional
- B. Lock-Out Tag-Out Devices: Provide permanently installed lock-out tag-out devices compliant with NFPA 70 and OSHA, with padlocking provisions, at source overcurrent devices for the following applications.
1. Where the normal NFPA 70-compliant location of the disconnecting means is impracticable or introduces additional or increased hazards to persons or property.
  2. Where required by NFPA 70.
  3. Where required by OSHA.
  4. Where required by any other authority having jurisdiction.
- C. Electrical Installations:
1. Install conduit, wiring, outlet box and junction box type work in finished areas concealed. Such work installed in unfinished areas may be exposed only at the discretion of the Owner's Representative.
  2. All new electrically related work shall be supported directly from building structural members. New electrically related work shall not be supported from ductwork, ductwork hangers, ceiling supports, existing conduit supports, etc. All conduits (and cable assemblies, where applicable) shall be routed parallel to building structural members. Noncompliant work installed by the electrical contractor shall be removed and reinstalled to the satisfaction of the Owner's Representative and the Design Professionals, at the expense of the electrical contractor.
  3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.



4. Provide systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and architectural/structural components. Provide factory-furnished filler plates in unused spaces of manufactured equipment.
5. Install electrical equipment to facilitate servicing, maintenance, and repair and replacement of equipment components. Install equipment for ease of disconnecting, with minimum of interference with other installations. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope. Protect the structure, furnishings, finishes, and adjacent materials.
6. Verify dimensions by field measurements. Take measurements and be responsible for exact size and locations of openings required for the installation of work. Where detailed method of installation is not indicated or where variations exist between described work and approved practice, follow direction of the Owner's Representative.
7. Provide no wire size smaller than No. 12 for branch circuits unless otherwise noted on plans for control circuits, or otherwise indicated in a Division 26 specification section. Provide larger sizes where required by prevailing codes or indicated on contract documents. Provide neutral conductor for all multi-pole feeders. Provide grounded ("neutral") conductor(s) for all multi-pole feeders and branch circuits unless this contractor determines in field that the affected load(s) will never have need for a neutral conductor and NEC does not mandate otherwise. Provide minimum 3/4" conduit size.
8. Do not install device wall outlets directly back to back, where located on opposite sides of common walls. Offset outlets by at least two feet for applications in fire rated walls and smoke rated walls and applications in acoustically treated walls. Offset outlets by at least one foot for other applications.
9. Provide wires continuous from outlet to outlet and properly splice joints. Provide insulation value for joints 100% greater than that of the wire. Mechanical wire splicers may be used. Where friction and rubber tape is used, provide tape conforming to Federal Specifications HH-T-11 and HH-T-111. Where plastic electrical tape is used, provide Scotch #33, or approved equal. Provide minimum 8" tail for conductors terminating at each wired outlet at their outlet fittings to facilitate installment of devices, luminaires, etc.
10. Use of synthetic or plastic "tie-wraps", "zip ties", "wire ties" and similar products are not permitted as a permanent means of anchoring, securing, supporting or otherwise installing any cables, conductors, conduits, raceways, devices, equipment or other electrical work.
11. If during construction it becomes apparent that some specific minor changes in layout will result in a neater job or better arrangement, make such alterations without additional compensation and without having to offer credit. Obtain Design Professional's review before making such changes. Provide workmanship throughout that conforms to the standards of best practice. Marks, dents and finish scratches are prohibited on exposed materials, luminaires, fittings, etc. Clean inside of panels and equipment boxes.
12. Special Occupancies: Provide all electrical work in Special Occupancies as defined and described in Chapter 5 of NFPA 70 in strict compliance with Chapter 5 of NFPA 70, in addition to compliance with specified and drawn requirements of Division 26.

**D. Connectors and Connections:**

1. Provide complete assembly of materials for each type of required electrical connection, including but not limited to, pressure connectors, terminals (lugs), electrical insulating tape, heat-shrinkable insulating tubing, solderless wire-nuts, and other items and accessories as needed to complete splices and terminations of types indicated.
2. Unless otherwise indicated, provide wires/cables (conductors) for electrical connections that match, including sizes and ratings, of wires/cables that are supplying electrical power. Provide electrical connectors and terminals that mate and match, including sizes and ratings, with equipment terminals, and that are recommended by equipment manufacturer for intended applications. Provide connectors that are specifically UL listed and labeled for



the exact splicing/termination application, including for instances where solid conductors are spliced/connected to stranded conductors. Provide electrical insulating tape, heat-shrinkable insulating tubing and boots, wirenuts, cable ties, etc. as recommended for use by accessories manufacturers for intended applications.

3. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment. Cover splices with electrical insulating material to achieve insulation at least 100 percent in excess of electrical insulation rating of those conductors being spliced. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Do not "ring" copper conductors while skinning wire.
4. Ground metal frames of portable and stationary direct-wired electrically operated equipment by connecting frames to the circuit equipment grounding conductor and to grounded metal raceway. Provide necessary electrical connections between the specified equipment and junction boxes, disconnect switches, and starters near equipment with flexible metallic conduit and matched connectors. Do not expose flexible conduit in finished areas.
5. Wire and connect electrical equipment furnished under this branch of work, other branches of work and by the Owner. Review documents of other trades to identify electrically operated/controlled equipment that is furnished or installed by the Owner, or by other trades. Provide power connections and local disconnects for same. Provide control wiring (including relays, starters, etc.), as required to render equipment fully operable unless indicated otherwise on drawings or in project manual. Determine exact requirements in field from respective equipment installer.

## **PART 2 - PRODUCTS (INCLUDED IN PART 1 ABOVE AS APPLICABLE)**

## **PART 3 - EXECUTION (INCLUDED IN PART 1 ABOVE AS APPLICABLE)**

**END OF SECTION 26 0502**

**SECTION 26 0503****SUBMITTALS FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 GENERAL**

- A. The contractor is not relieved of responsibility for providing specified or drawn scope of work should any errors or omissions in submittal information not be noted by the Design Professional during submittal reviews or site observations.
- B. Submittal requirements of this section apply to all Division 26 sections. Note that some Division 26 sections may also have additional requirements that are unique to the specific section, which would be requirements in addition to those stated in this section. Furnish submittals for each Section that includes one or more of the following elements of work: supply, installation, integration, programming, creation, labeling, and/or contractor-based design or engineering, of one or more products or systems. If a manufacturer is proposed but not listed in a particular specification section, submit as a substitute.
- C. Furnish submittals in electronic (PDF) format. Provide electronic submittal files that are compatible for opening and viewing with electronic PDF file readers that fully support and recognize the Adobe PDF Portable Document Format Standard. Assemble single PDF file submittals from a series of individual files that are organized, indexed, bound together as one composite file that is bookmarked if needed to aid the reviewer in navigating the content. The file name used to label the submittal shall be the section number followed by the submittal instance number for that Section (e.g., 260519-PD-01.pdf).

**PART 2 - PRODUCTS (NOT USED)****PART 3 - EXECUTION****3.1 GENERAL**

- A. Route submittals through established Project channels as identified by the Owner's Representative. Coordinate, assemble, title, transmit and track Project submittals. Label each submittal of each type similarly for consistency and so they appear as if prepared by the same entity. Like-type submittals (e.g., Product Data) from different Sections shall have the same appearance and organization as those of other Sections. Submittal items listed in this Section represent the common items required to be supplied for the various specification Sections throughout the duration of the Project. Individual Sections may include additional requirements. Design Professional reserves the right to require additional submittals or to waive select submittal requirements on a Section-by-Section basis.
- B. Furnish submittals for all materials proposed for use for the project, using products compliant with all respective specifications and with information shown on drawings. Furnish submittals for different Sections each with its own transmittal form. A single transmittal shall not be used to identify submittals for more than one (1) Section at a time. Organize submittals as identified in

the Contract Documents. Supply separate submittals for each Section. Do not combine multiple Sections together into a single submittal, except where expressly directed within the Contract Documents. The format for labeling the submittals shall be as follows: Section Number–Submittal Type Abbreviation–Submittal Iteration (examples: First Product Data Submittal for Section 260519: “260519-PD-00”; revised Product Data Submittal for Section 260519: “260519-PD-01.”).

### **3.2 SUBMITTAL REQUIREMENTS**

- A. General:
1. Transmittal: Supply a dedicated transmittal for submittals for each individual Section. Itemize the specific submittals included by Section, submittal type, and iteration.
  2. Title Sheet: Include a separate title sheet (including index) with each submittal, of each type. Title sheets for each Section, for each submittal type, shall have the same appearance, 8-1/2 inches x 11 inches for product data submittals. Title sheets for drawings shall be the same size as the associated drawings. Create title sheets with appearance and information identified on the sample title sheet at the end of this Section.
  3. Title Blocks: Create drawing submittals on the Contractor's, manufacturers, or vendor's own title block, not using those of the Owner, Design Professionals or their Consultants.
  4. Legend: Drawing submittals shall include a legend of symbology.
  5. Resubmittals: Resubmittals shall include a replica of the reviewer's comments that necessitated the resubmittal, along with an accompanying item-by-item explanation of the actions taken and changes that will be found within the resubmittal.
  6. Submittal requirements indicated in this section apply for all specification sections with products and materials, and are supplemental to and in addition to submittal requirements that may be included in product and material specification sections.
- B. Informational Submittals – Submit this information as part of the Operations and Maintenance Manual.
1. Product Certificates: For each applicable product or system, from manufacturer.
  2. Source quality-control test reports.
  3. Field Quality-Control Reports:
    - a. Test procedures used.
    - b. Test results that comply with requirements.
    - c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Quality Assurance Submittals (QA):
1. Furnish upon request when not expressly requested to be supplied with bid. When requested, furnish to the Design Professional within 2 business days.
    - a. Qualification Data for testing agencies, including detailing of scope of services for the project.
    - b. Furnish list of Subcontractors to be used on the Project along with a description of the role each shall play on the Project, and the last six (6) projects that the Contractor (and each proposed Subcontractor) has completed that are of similar scope, size and contract value.
- D. Product Data Submittals (PD): Submit following contract award or notice of intent to award a contract. Submit and obtain review(s) prior to procurement or fabrication of materials. Provide separate manufacturer datasheets for each product, which shall be manufacturer originals of the manufacturer's official electronic datasheet. Distributor modified, distributor branded, and/or html based “web” datasheets are not acceptable. For all materials, equipment, components and

ancillary materials, include the following as applicable: voltage; phase; frequency; short circuit ratings; load; dimensions; technical data; enclosure types; required clearances; weights; methods of field assembly and installations; diagrams; configurations; capacities; finishes; construction; overcurrent protection; features; performance; electrical characteristics ratings; finishes; accessories; NRTL listing for series rated devices; time-current coordination curves for each type and rating of overcurrent protective device, including selectable ranges for each; all pertinent technical support data; factory settings; etc. Where manufacturer's datasheets depict multiple products, versions and options, indicate via highlighting, underlining, or bold visible arrows the models, versions, colors, options, etc. being supplied. Indicate and identify exact catalog numbers. Comply with applicable standards of UL or NRTL.

- E. Shop Drawing Submittals (SD): Submit following contract award or notice of intent to award a contract. Submit and obtain review(s) prior to procurement or fabrication of materials. Submit concurrently with section-specific product data submittals where both apply. Draw plans, elevations, sections, elevations and sizes to scale. Show and details, features, characteristics, ratings, factory settings, nameplates, legends, bus structure, capacities, features, accessories, locations of pertinent items, schematics, wiring diagrams, production drawings, etc. Furnish schematic drawings with all information required to install, identify, connect, wire, program, maintain, etc. the system(s). Comply with applicable standards of NRTL.
- F. Sample Submittals (SS): Submit concurrent with, or soon after, product data and shop drawings and prior to installation of Work. Furnish physical samples where applicable, in quantities as directed by Owner's Representative.
- G. Training Submittals (TG): Submit thirty (30) days prior to the first training session. Furnish proposed schedule, training agendas for each session, identification of personnel that will conduct training, and handouts proposed for distribution during training. Record all training sessions and include within O&M Manual.
- H. Closeout Submittals (CO):
  - 1. Submit following completion of onsite work.
  - 2. Operation and Maintenance Manuals:
    - a. Provide on USB drive(s). Provide sub-directories on the drive(s) to label and separate contents for the manual.
  - 3. As-Built Drawings
    - a. Provide on USB drive(s).
- I. Extra Materials: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Generate report indicating all maintenance materials turned over to owner and obtain signature from owner acknowledging receipt.

### **3.3 SUBMITTAL RESPONSES**

- A. Revise and Resubmit: When a submittal is marked "Revise and Resubmit," the entire submittal shall be reviewed, revised and resubmitted in totality unless specifically indicated otherwise. Resubmittals shall be checked for compliance with the Contract Documents, inclusive of requirements for submittals. In addition, any comments and deficiencies identified by the reviewer shall be appropriately acted upon. Uniquely identify specific portions of each resubmittal that have been modified since the previous version was reviewed. Resubmittals

shall include a copy of the reviewer's previous comments, include a written description of the action(s) taken, be labeled chronologically, and be inclusive of all corrective action identified by the previous reviewer.

- B. Exceptions Noted: When a submittal is marked "Exceptions Noted," the specific actions identified shall be taken. No further submittal actions required
- C. No Exceptions: When a submittal is marked "No Exceptions", no further actions are required.

**END OF SECTION 26 0503**

SUBMITTAL TITLE SHEET

EXAMPLE

(Form: Sub-1)

PROJECT TITLE:

Project Name Line 1

Project Name Line 2

Project Name Line 2

SUBMITTAL TYPE:

Product Data

SECTION SUBMITTAL NUMBER

260519-PD-00

SECTION TITLE:

Section Name

Date Prepared:

yyyy-mm-dd

CONTRACTOR OF RECORD:

Firm Name

Address 1

Address 2

City, State, Zip

Phone (000) 000-0000, Fax (000) 000-0000

Project Manager: Full Name

PM E-Mail: xxxxxxxx@xxxx.xxx

SECTION SUBCONTRACTOR(S):

Firm Name

Address 1

Address 2

City, State Zip

Phone (000) 000-0000

Fax (000) 000-0000

PM Name: Full Name

PM E-Mail: xxxxxxxx@xxxx.xx

Firm Name

Address 1

Address 2

City, State Zip

Phone (000) 000-0000

Fax (000) 000-0000

PM Name: Full Name

PM E-Mail: xxxxxxxx@xxxx.xx

**SECTION 26 0519****LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For each type of conductor and cable.

**PART 2 - PRODUCTS****2.1 CONDUCTORS AND CABLES**

- A. Acceptable Manufacturers: Subject to being equivalent and subject to compliance with requirements, provide product by one of the manufacturers listed below, or by an NRTL listed equivalent manufacturer.
  - 1. Alcan Products Corporation; Alcan Cable Division.
  - 2. Alpha Wire.
  - 3. Belden Inc.
  - 4. Encore Wire Corporation.
  - 5. General Cable Technologies Corporation.
  - 6. Southwire Incorporated.
  - 7. American Insulated Wire Corp
  - 8. Republic Wire
- B. Conductor Insulation and Multiconductor Cables: Comply with NEMA WC 70/ICEA S-95-658. Refer to Part 3 of this section for allowable types specific to this project.
- C. MC Cable (Metal-Clad):
  - 1. Provide Type MC Cables that are minimum 90 degrees C rated, with components and fittings listed for grounding, compliant with NEC Articles 250 and 330.
  - 2. Provide cable formed from continuous length of spirally wound, interlocked zinc coated or galvanized (inside and outside) strip steel or aluminum jacket. Provide cables with full parity insulated equipment ground conductor.
  - 3. Provide compatible steel fittings with integral red plastic insulated throat bushings, compliant with NEC 330.

**2.2 CONNECTORS AND SPLICES**

- A. Acceptable Manufacturers: Subject to being equivalent and subject to compliance with requirements, provide products by one of the manufacturers listed below, or by an NRTL listed equivalent manufacturer.
  - 1. AFC Cable Systems, Inc.
  - 2. Gardner Bender.
  - 3. Hubbell Power Systems, Inc.
  - 4. Ideal Industries, Inc.

5. IIsco; a branch of Bardes Corporation.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of the EGS Electrical Group.
8. 3M; Electrical Markets Division.
9. Tyco Electronics.
10. Square D, a Schnieder Electric Company
11. Thomas & Betts
12. Arrow-Hart Div, Crouse-Hinds Co

- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

### **PART 3 - EXECUTION**

#### **3.1 APPLICATIONS AND INSTALLATION**

- A. Provide conductor insulation rated at 600VAC and 90 degrees C. Provide wire, cable and connectors suitable for the temperature, conditions and location where installed. Provide THHN/THWN insulation for conductors 500 kcmil and larger, and for conductors # 8 AWG and smaller. Provide THW or THHN/THWN insulation for other sizes as appropriate for the locations where installed. Provide XHHW-2 insulation for wiring below grade and for wiring subject to moisture conditions.
- B. Grounded ("Neutral") Conductors: Provide dedicated parity sized grounded ("neutral") conductor for each branch circuit phase conductor fed from 15-ampere and 20-ampere branch circuit breakers. Provide grounded ("neutral") conductor in all lighting control device (switch, dimmer, occupancy sensor, etc.) wall outlet boxes, even if not immediately used. Provide grounded ("neutral") conductor for all multi-pole feeders. Provide grounded ("neutral") conductor(s) for all multi-pole feeders and branch circuits unless this contractor determines in field that the affected load(s) will never have need for a grounded ("neutral") conductor and NEC does not mandate otherwise.
- C. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables. Use manufacturer UL approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install wire in raceway unless specifically permitted otherwise in this specification section, under other Division 26 sections, or on electrical drawings. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Do not pull wire until raceways are complete, plastering is complete, and raceways are free of moisture. Install joints and splices only at NEC approved panels, accessible junction boxes, or accessible outlet boxes. Pull conductors simultaneously where more than one is being installed



in same raceway. Use UL listed pulling compound or lubricant, where necessary to prevent damage to conductors. Use pulling means, including fish tape, cable, rope, and basket weave wire/cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to wire or cable. Conceal work in finished spaces.

- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems." Use of synthetic or plastic "tie-wraps", "zip ties", "wire ties" and similar products are not permitted as a permanent means of anchoring, securing, supporting or otherwise installing any cables, conductors, conduits, raceways, devices, equipment or other electrical work.
- G. Neatly dress work. Install work parallel and perpendicular to surfaces and exposed structural members, and follow surface contours where possible. Keep conductor splices to minimum. Install splice and tap connectors that possess equivalent, or better, mechanical strength and insulation rating than conductors being spliced. Use splice and tap connectors that are compatible with conductor material. Install wires continuous from outlet to outlet. Provide insulation value of joints at least 100 percent more than that of the wire insulation. Provide adequate length of conductors within electrical enclosures, and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- H. De-rate cables per NFPA 70 where bundled, where passing through insulation, and where otherwise required to be compliant with NFPA 70 based on field conditions and/or means and methods that will be used. De-rate conductors per NFPA 70 where required based on quantities of conductors within raceways, and where otherwise required to be compliant with NFPA 70 based on field conditions and/or means and methods that will be used.
- I. Type MC cable may be utilized only if NEC approved and if approved by local authority having jurisdiction and if included in the limited applications defined below.
  - 1. Provide for final connections to luminaires that are installed in accessible tile ceiling systems (limited to 6' maximum in length and limited to "whips" from building electrical system junction boxes down to luminaires). Do not install Type MC cable from fixture to fixture unless a special properly listed and labeled UL approved system is specifically indicated.
  - 2. Provide only where concealed (install wiring for exposed applications in raceway).
  - 3. Route cables perpendicular and parallel to the building architectural lines, surfaces, and structural members, keeping offsets to a minimum and following surface contours where possible. Maintain a uniform elevation for cable runs wherever possible. Support and anchor cables at maximum 4-foot intervals and within 12" of box or outlet in a manner that prevents sagging. Install cables in a manner that prevents overheating. Fasten cables directly to the structure using factory clamps and clips specifically designed for the respective cable (Caddy or equal).

### **3.2 CONNECTIONS**

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors. Install conductor at each outlet with at least 8 inches of slack.

- B. Provide complete assembly of materials for each type of required electrical connection, including but not limited to, pressure connectors, terminal (lugs), electrical insulating tape, heat shrinkable insulating tubing, cable ties, solderless wire-nuts, and other items and accessories as needed to complete splices and terminations of types indicated.
- C. Unless otherwise indicated, provide wires/cables (conductors) for electrical connections that match, including sizes and ratings, of wires/cables that are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 90 degrees. Provide factory splice kits (U.L. approved for submersion in water and direct burial) for wire splicing in outdoor grade, or slab on grade, junction boxes and for all other wet locations.
- D. Provide electrical connectors and terminals that mate and match, including sizes and ratings, with equipment terminals, and that are recommended by equipment manufacturer for intended applications. Connect wires #6 AWG and larger to panels and apparatus by means of approved lugs or connectors large enough to enclose all strands of the conductors. Provide solderless type connectors
- E. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment. Cover splices with electrical insulating material to achieve insulation at least 100 percent in excess of electrical insulation rating of those conductors being spliced. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Do not "ring" copper conductors while skinning wire.
- F. There may be cases where circuit or feeder conductor sizes are too large or too small to fit into the lugs normally supplied with the power distribution equipment or end-use equipment, due to circumstances such as increasing conductor sizes to offset voltage drop, unusual breaker frame sizes, type of conductors used, etc. In such cases provide appropriate factory lug kits for affected equipment if recommended by manufacturer; elsewhere provide insulated butt-splices with tails sized to fit respective lugs.
- G. Ground metal frames of portable and stationary direct-wired electrically operated equipment by connecting frames to the circuit equipment grounding conductor and to grounded metal raceway. Provide necessary electrical connections between the specified equipment and junction boxes, disconnect switches, and starters near equipment with flexible metallic conduit and matched connectors. Do not expose flexible conduit in finished areas.

### **3.3 CONDUCTOR SIZING**

- A. Conductor sizes indicated in Division 26 documents are based on copper unless specifically indicated otherwise on single-line diagram on drawings.
- B. Provide minimum #12 AWG conductor size, unless specifically indicated otherwise on drawings.

- C. Unless specifically indicated otherwise on drawings, provide grounded ("neutral") conductors that are at least parity-sized with corresponding phase/line conductors for all applications.

**END OF SECTION 26 0519**

**SECTION 26 0529****HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL (NOT USED)****PART 2 - PRODUCTS****2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly. Construct with 9/16" dia. holes, nominal 2" o.c. on top surface, with standard factory finish, and with the all necessary fittings which mate and match with U-channel. Select channel dimensions for applicable load criteria. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Allied Tube & Conduit
  - 2. Caddy
  - 3. Cooper B-Line, Inc.; a division of Cooper Industries
  - 4. ERICO International Corporation
  - 5. GS Metals Corporation
  - 6. Hilti
  - 7. Powers
  - 8. Thomas & Betts Corporation
  - 9. Unistrut; Tyco International, Ltd.
  - 10. Wesanco, Inc.
  - 11. Perma-Cote
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
  - 1. Riser clamps for supporting rigid metal conduit; galvanized steel; with 2 bolts and nuts, and 4" ears.
  - 2. Clevis hangers: For supporting rigid metal conduit; galvanized steel; with 1/2" dia. hole for round steel rod.
  - 3. Galvanized steel clamps; 1/2" rod size.
  - 4. Galvanized steel clamps, 1-1/4" x 3/16" stock; 3/8" cross bolt; flange width 2".
  - 5. One-hole conduit straps for supporting 3/4" rigid metal conduit; galvanized steel.
  - 6. Two-hole conduit straps for supporting 3/4" rigid metal conduit, galvanized steel; 3/4" strap width; and 2-1/8" between center of screw holes.
  - 7. Offset conduit clamps for supporting rigid metal conduit; galvanized steel.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following.
  - 1. Products: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Cooper B-Line, Inc.; a division of Cooper Industries.
    - b. Empire Tool and Manufacturing Co., Inc.
    - c. Hilti, Inc.
    - d. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
    - e. MKT Fastening, LLC.
    - f. Simpson Strong-Tie Co., Inc.
  - 2. Capacities: Provide materials and installed systems with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used, plus 100% safety factor.
  - 3. Mechanical-Expansion Anchors in Dry Conditioned Areas: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement Provide stainless steel anchors where located in areas subject to moisture or corrosion.
  - 4. Drop-In Anchors: AISI Type 303 stainless steel, drop-in, shell or flush type, equivalent to Hilti HDI series.
  - 5. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
  - 6. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 7. Through Bolts: Steel structural type, hex head, and high strength. Comply with ASTM A 325.
  - 8. Toggle Bolts: All-steel galvanized springhead type, minimum 3/16" x 4".
  - 9. Hanger Rods: Threaded steel, Galvanized steel rods; 1/2" minimum diameter.
  - 10. Clevis hangers: For supporting rigid metal conduit; galvanized steel; with 1/2" minimum diameter hole for round steel rod.
  - 11. Galvanized steel rod reducing couplings: 1/2" x 5/8" minimum.
  - 12. Galvanized steel clamps: 1/2" minimum rod size; Galvanized steel clamps: Minimum 1-1/4" x 3/16" stock; minimum 3/8" cross bolt; minimum flange width 2".
  - 13. Hexagon nuts: Galvanized steel.
  - 14. Expansion anchors: Minimum 1/2".

## **PART 3 - EXECUTION**

### **3.1 APPLICATIONS AND INSTALLATION**

- A. It shall be the responsibility of the electrical contractor to supervise the installation of and pay for all additional members, wood or metal and labor which may be required to support any type of permanent or temporary electrical apparatus employed in the execution of the electrical contractor's work. Provide supports, anchors, sleeves and seals furnished as part of factory-fabricated equipment as required.
- B. Coordinate layout and installation of equipment and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

- C. Provide supports for multiple raceways capable of supporting combined weight of supported systems and its contents, plus minimum 100% factor of safety. Provide equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components. Provide rated strengths adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this project, with a minimum structural safety factor of five times the applied force.
- D. Locate all structural elements within concrete prior to pre-drilling anchors. Contractor is responsible for repairing all damage to structural elements resulting from the scope of this work. Anchor hole dimensions shall be per manufacturer recommendations. Drill and install anchors to depths as recommended by respective anchor manufacturer. Select and apply anchor products based on collective weight being supported, plus 100% factor of safety.
- E. Comply with NECA 1 and NECA 101 for application and installation requirements of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- F. All electrically related work shall be supported directly from building structural members. Electrically related work shall not be supported from ductwork, ductwork hangers, ceiling supports, existing conduit supports, etc. Install supports with spacing's indicated and in compliance with NEC requirements, including all requirements of Article 110.26. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- G. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment. Field Welding: Comply with AWS D1.1/D1.1M.
- H. Touchup Painting: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils. For galvanized surfaces, clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- I. Install equipment and enclosures on walls with tops at uniform height unless otherwise indicated, and by bolting units to structural wall or mounting on structural-steel channels bolted to wall. For equipment and enclosures not at walls, provide freestanding structural-steel channel racks that are anchored to floor structure and overhead structure.
- J. Use of synthetic or plastic "tie-wraps", "zip ties", "wire ties" and similar products are not permitted as a permanent means of anchoring, securing, supporting or otherwise installing any cables, conductors, conduits, raceways, devices, equipment or other electrical work. Provide metal clamps, clips, etc. that are manufactured for use for respective applications where they are used. Use of perforated straps is not permitted.
- K. Route all conduits, raceways and cables (where applicable) parallel and perpendicular to building structural members. Any and all noncompliant work installed by the electrical contractor shall be removed and reinstalled by the electrical contractor to the satisfaction of the Owner's Representative and the Design Professionals, at the expense of the electrical contractor.

- L. All fasteners, hangers and methods of hanging exposed work in finished areas shall be submitted to the Owner's Representative for review before installation. Fasteners shall be zinc-coated, type, grade, and class as required for a neat finished installation.
- M. Space supports for conduits and raceways required by NFPA 70 as a minimum. Minimum rod size shall be 1/4 inch in diameter. For multiple raceways or cables, install trapeze-type supports fabricated with steel slotted, sized so capacity can be increased by at least 100 percent in future without exceeding specified design load limits. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps, or single-bolt conduit clamps using spring friction action for retention in support channel as applicable.
- N. Coordinate with installation of roof curbs, equipment supports, and roof penetrations as applicable. Install work so that no raceway or cable is within six inches below roof deck(s). Suspend and support overhead electrical work from roof trusses and joists/joist girders only at panel points, at top chord only, unless otherwise indicated.
- O. Do not drill any concrete structural members or decks without prior case-by-case written approval of means and methods from Owner and Design Professionals.
- P. Support overhead hangers supported from poured-concrete decks using stainless steel threaded inserts, with approval of means and methods obtained from Owner and Design Professionals.
- Q. Field-verify lengths of stems, pendants, cables, suspensions, etc. for all suspended luminaires with Owner's Representative.
- R. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb. or 100 percent factor of safety, whichever is greater.
- S. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded. Install anchor bolts to elevations required for proper attachment to supported equipment. Install anchor bolts according to anchor-bolt manufacturer's written instructions. Provide female expansion anchors, and install studs and nuts after equipment is positioned. Torque bolts and nuts on studs to values recommended by equipment manufacturer. Provide bushings for floor-mounted equipment anchors to allow for resilient media between anchor bolts/studs and mounting hole in concrete. Provide anchor bolt bushing assemblies for wall-mounted equipment to allow for resilient media where equipment and equipment-mounting channels are attached to wall.
  - 1. To Wood: Fasten with lag screws or through-bolts. Provide Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPB rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent. Provide marine grade products where subject to moisture conditions. Provide Simpson Strong Tie (or equal) expansion screw anchors. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will



- receive finish materials. Make tight connections between members. Install fasteners without splitting wood members. Attach to substrates as required to support applied loads.
  2. To Wood Structural Members: Provide bolts installed through members.
  3. To New Concrete: Provide channel-type concrete inserts and bolt to inserts, or provide expansion anchors for applications where inserts are not practical.
  4. To Existing Concrete: Expansion anchor fasteners.
  5. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars and other structural elements. Review proposed means, methods, locations, etc. in advance with Owner and Design Professionals.
  6. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  7. To Steel: Welded threaded steel studs complying with AWS D1.1/D1.1M, with lock washers and nuts, or beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69, clamped to flanges of beams or on upper truss chords of bar joists.
  8. To Light Steel: Sheet metal screws.
  9. Items Mounted on Hollow Walls and Nonstructural Building Surfaces in finished areas: Provide blocking between studs behind finished wall surface. Mount equipment, devices and boxes with backs of enclosures flush to front of finished wall surface.
  10. Items Mounted on Hollow Walls and Nonstructural Building Surfaces in unfinished areas: Mount equipment on slotted-channel racks attached to substrate.
- T. Coordinate all work with all other trades prior to commencement of the work. Layout and install all electrical work in strict compliance with Chapter 1, Part B, Section 110.26 of the latest adopted edition of NFPA 70. Locations and routing that may be shown on plans are schematic and diagrammatic in nature.
- U. Fabricated Support Devices:
1. Conform to the manufacturer's recommendations for selection and installation of supports.
  2. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
  3. Support parallel runs of horizontal raceways together on trapeze-type hangers.
  4. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners shall be used in lieu of hangers for 1-1/2 inches and smaller raceways above suspended ceilings only.
  5. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits.
  6. Support exposed and concealed raceway within 1 foot of box and access fittings. In horizontal runs, support at the box and access fittings shall be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
  7. In vertical runs, arrange supports so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on the ends of the raceway.
  8. Miscellaneous supports:
    - a. Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, pull boxes, junction boxes, and other devices.
    - b. Support outlet boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.



- c. Support junction boxes, pull boxes and other boxes directly from the building structure.
- 9. Fastening:
  - a. Fasten pathway products and associated supporting hardware securely to the building structure.
  - b. Fasten by means of wood screws on wood, toggle bolts on hollow masonry units.
  - c. Fasten by means of concrete inserts or expansion bolts on concrete or solid masonry.
  - d. Fasten by means of bolts with lock washers and nuts, machine screws, welded threaded studs, or clamps on steel (spring-tension where applicable).
  - e. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures.
  - f. In partitions of light steel construction, use sheet metal screws.
  - g. When installing fasteners in concrete or CMU structures, do not cut, drill or damage reinforcing bars or other structural elements.
  - h. Ensure that the load applied to any fasteners does not exceed 25-percent of the proof test load. Use vibration-and shock-resistant fasteners for attachments to concrete slabs.
  - i. Raceway supports: Hanger spacing shall be as required for adequate support of the raceway, but in no case shall there be less than one hanger per 8 feet of raceway length.
- 10. Locate all structural elements within existing concrete prior to pre-drilling or setting anchors. Contractor is responsible for repairing all damage to structural elements resulting from the scope of this work.

**END OF SECTION 26 0529**

**SECTION 26 0533****RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For surface raceways, wireways, fittings, boxes, enclosures, and cabinets.
- B. Definitions
  - 1. EMT: Electric metallic tubing.
  - 2. FMC: Flexible metallic conduit.
  - 3. GRC/RMC: Galvanized rigid steel conduit.
  - 4. IMC: Intermediate metal conduit.
  - 5. LFMC: Liquid-tight flexible metallic conduit.
  - 6. RNC: Rigid nonmetallic conduit.
  - 7. Conduit/Raceway/Pathway: "Conduit", "raceway", "pathway" and similar terms shall be taken to mean "conduit" unless specifically indicated otherwise in project manual documents, or unless specifically directed otherwise in field by Owner or Design Professionals. All such terms shall be considered synonymous for the general purposes of installation means and methods.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS**

- A. Products: Metal conduits, tubing, boxes and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Subject to compliance with requirements, manufacturers offering raceway, box and fitting related products that may be incorporated into the Work as applicable include, but are not limited to, the following:
  - 1. Allied
  - 2. Adalet.
  - 3. AFC Cable Systems, Inc.
  - 4. Allied Tube & Conduit; a Tyco International Ltd. Co.
  - 5. Anamet Electrical, Inc.
  - 6. Appleton Electric.
  - 7. Armormat Products Company
  - 8. Arnco Corporation
  - 9. Baxter
  - 10. Bell Electric.
  - 11. Bowers.
  - 12. Cantex.
  - 13. Carlon.
  - 14. Carson Industries LLC
  - 15. CDR Systems Corporation; Hubbell Power Systems
  - 16. CertainTeed Corp.

17. Condux International, Inc.
18. Cooper
19. Eagle Electric Mfg Co., Inc.
20. Efcor.
21. EGS/Appleton Electric
22. Electri-Flex Company.
23. Erickson Electrical Equipment Company
24. FSR
25. General Electric Company
26. Highline Products
27. Hoffman; a Pentair company.
28. Hubbell.
29. Kraloy.
30. Lamson & Sessions; Carlon Electrical Products
31. LTV.
32. Midland-Ross Corp.
33. Milbank Manufacturing Co.
34. Mono-Systems, Inc.
35. NewBasis
36. Niedax-Kleinhuis USA, Inc.
37. Nordic Fiberglass, Inc
38. Norwalk
39. O-Z/Gedney; a brand of EGS Electrical Group.
40. Oldcastle Precast, Inc.; Christy Concrete Products
41. Panduit
42. Pass and Seymour, Inc.
43. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
44. Quazite
45. RACO
46. Regal.
47. Republic Conduit.
48. Robroy Industries.
49. Siemens/ITE
50. Southwire Company.
51. Spring City Electrical Manufacturing Company
52. Square D; a brand of Schneider Electric.
53. Stahlin Non-Metallic Enclosures; a division of Robroy Industries
54. Steel City.
55. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
56. Tay-Mac
57. Thepitt.
58. Thomas & Betts Corporation.
59. Walker/Wiremold/Legrand
60. Western Tube and Conduit Corporation.
61. Westinghouse/Cutler-Hammer
62. Wheatland Tube Company; a division of John Maneely Company.
63. Wiegmann (Hubbell-Wiegmann)

## **2.2 METAL CONDUITS, TUBING, AND FITTINGS**

- A. EMT: Comply with FS WW-C-563, ANSI C80.3 and UL 797.
- B. IMC: Comply with ANSI C80.6 and UL 1242.

- C. GRC/RMC: Comply with ANSI C80.1 and UL 6. Provide steel conduit, galvanized/fused to inside and outside walls of conduit and fittings after fabrication and after threading.
- D. FMC: Comply with FS WW-C-566 and UL 1; zinc-coated steel. Provide flexible metal conduit formed from continuous length of spirally wound, interlocked zinc-coated or galvanized (inside & outside) strip steel. Provide conduit fittings for use with flexible steel conduit of threadless hinged clamp type, with insulated throats. Provide Straight Terminal Connectors consisting of one-piece body, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end with locknut. Do not use 45-degree or 90-degree Terminal Angle Connectors for flexible or water-tight flexible metal conduit in locations that will not be fully accessible after completion of construction. Provide full size green insulated ground wire for all applications, regardless of length.
- E. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
1. Provide liquid-tight flexible metal conduit formed from continuous length of spirally wound, interlocked, double-wrapped hot-dipped zinc-galvanized (inside & outside) steel core. Provide liquid-tight jacket of flexible polyvinyl chloride (PVC) that is fully weatherproof, flame-retardant, heat resistant, oil resistant, sunlight resistant and that resists heat, oil and chemical breakdown.
  2. Provide smooth-wall type jackets (not a corrugated look) for furniture whip (and similar) applications in indoor finished areas.
  3. Provide Liquid-Tight Flexible Metal Conduit Fittings compliant with FS W-F-406, Type 1, Class 3, Style G. Provide cadmium plated, malleable iron fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated throat.
  4. Provide Straight Terminal Connectors that are one-piece body, female ends with clamps and deep slotted machine screws for securing conduits, and male threaded ends with locknuts.
  5. Provide Terminal Angle Connectors that are 45-degree or 90-degree two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut. Do not use 45-degree or 90-degree Terminal Angle Connectors for flexible or water-tight flexible metal conduit in locations that will not be fully accessible after completion of construction.
  6. Provide full parity size green insulated ground wire for all applications, regardless of length.
  7. Provide installed LFMC systems using materials and installation methods that result in IP67 compliant.
- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. EMT: Provide steel, galvanized or zinc-coated water/concrete-tight fittings; do not use die-cast fittings. Provide Compression type for outdoor applications, and applications in other wet locations. Provide Compression or set screw type for indoor applications.
  2. GRC/RMC: Zinc-Galvanized Steel (after fabrication/factory-threading), threaded (fused-galvanized after threading.)
  3. Expansion Fittings: Material to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
  4. Provide terminal conduit fittings with insulated throats, or plastic bushings for conduits 2" and larger where insulated throats may not be readily available.
  5. Provide locknuts for securing conduit to metal enclosure with sharp edge for digging into metal, and ridged outside circumference for proper fastening. Provide screw type grounding terminal for metal bushings of standard or insulated type.
  6. Provide miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that are specifically designed for their particular application.

7. Provide galvanized cast-metal (steel) conduit bodies of types, shapes and sizes as required to fulfill job requirements and NFPA 70 requirements. Construct conduit bodies with threaded-conduit-entrance ends, with removable covers, either cast or of galvanized steel, and with corrosion-resistant screws.
- G. Joint Compound for Threaded Conduit: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## **2.3 METAL WIREWAYS AND AUXILIARY GUTTERS**

- A. Metal Product Description: Provide sheet metal wireways, complying with UL 870 and NEMA 250, Type 1 for indoor applications and Type 3R for outdoor applications unless otherwise indicated, and sized according to NFPA 70. Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
  1. Provide screw-cover type for indoor applications, and flanged-and-gasketed type for outdoor applications unless otherwise indicated. Provide manufacturer's standard enamel finish. Protect sheet metal parts with rust inhibiting coating and baked enamel finish. Provide plate-finished hardware to prevent corrosion. Protect screws installed toward inside of wireway, with spring nuts to prevent wire insulation damage.
  2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Provide electrical wireways of types, grades, sizes, and number of channels for each type of applicable service.
  3. Provide lay-in wireways with hinged covers in accordance with UL 870, and with components UL-listed, including lengths, connectors, and fittings. Provide units that allow fastening of hinged cover closed without use of parts other than standard lengths, fittings and connectors. Provide units capable of sealing cover in closed position with sealing wire. Provide wireways with knockouts. Provide wireway connectors suitable for "lay-in" conductors, with connector covers permanently attached so that removal is not necessary to utilize the lay-in feature. Provide NEMA 3R units where used outdoors or in areas subject to moisture.
- B. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

## **2.4 BOXES, ENCLOSURES, AND CABINETS**

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be UL listed and labeled for use in wet locations, including cover plates and doors. Boxes, enclosures, and cabinets installed in damp and areas subject to moisture shall be UL listed and labeled for use in damp locations, including cover plates and doors. All other applications shall be UL listed and labeled for the location in which they are installed. Provide galvanized (after fabrication and after threading) boxes with galvanized or stainless-steel accessories, hardware and cover plates.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A. Provide galvanized-coated flat rolled code-gage non-gangable sheet-steel outlet/junction/pull boxes, of

shapes, cubic inch capacities, and sizes, including box depths as indicated, suitable for installation at respective locations. Construct outlet boxes with mounting holes and with cable and conduit-size knockout openings in bottom and sides where applicable. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding. Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps, and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Provide with stainless steel nuts, bolts, screws and washers.

- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover. Only use for special applications with prior case-by-case approval from Design Professionals.
- D. Luminaire Outlet Boxes: Comply with outlet box specifications above; nonadjustable, designed for attachment of luminaire weight (50 lb, minimum) plus 100 percent factor of safety. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight, including 100 percent factor of safety.
- E. Box extensions used to accommodate new building finishes shall be of same material as recessed box and shall extend to the finished wall surface.
- F. Bushings, knockout closures and locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.
- G. Device Box Dimensions: 4 inches square by 1-1/2 inches deep or 4 inches square by 2-1/8 inches deep, depending on device depths and wiring fill, with single-gang plaster/"mud" rings where only one device is being installed. Provide wider boxes for applications where more than two devices will be installed. Provide internal metal dividers where required under NFPA 70 for varying voltages, multiple circuits, etc. Gangable boxes (using multiple single-gang boxes to assemble multi-gang boxes) are prohibited.
- H. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 for indoor applications and Type 3R for outdoor applications with continuous-hinge cover with flush latch unless otherwise indicated, and with steel interior panels that are finished with manufacturer's standard enamel.
  - 1. Metal Enclosures: Stainless steel, or galvanized (after fabrication) steel, finished inside and out with manufacturer's standard enamel.
- I. Cabinets:
  - 1. Provide NEMA 250, stainless steel or Type 3R galvanized (after fabrication) steel boxes with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Provide hinged door in front cover with flush stainless-steel latch and concealed stainless-steel hinge. Provide key latch to match panelboards. Provide metal barriers to separate wiring of different systems and voltage. Provide accessory feet where required for freestanding equipment. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, listed by a qualified testing agency, and marked for intended location and application.

**PART 3 - EXECUTION****3.1 RACEWAY APPLICATION**

- A. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
  2. Exposed and Subject to Minor Physical Damage: EMT.
  3. Exposed and Subject to Moderate Physical Damage: GRC/RMC or IMC. Raceway locations include the following:
    - a. Mechanical rooms
  4. Concealed in Cavities of Ceilings and Interior Walls and Partitions: EMT.
  5. Above-Grade Damp or Wet Locations: GRC/RMC or IMC.
  6. Final 72 inches from accessible outlet/junction boxes to recessed luminaires that are located in accessible ceiling systems: FMC (or Type MC cable).
  7. Final 24-72 Inches at Connections to Vibrating Equipment or equipment that is subject to any degree of motion in its normal operation (Including But Not Limited To Transformers, Electric Solenoids, and Motor-Driven Equipment): FMC, except use LFMC in damp, wet or otherwise corrosive locations. Leave sufficient slack in flexible conduit to permit movement from vibration without adversely affecting conduits and connections.
  8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- B. Raceway Fittings: Compatible with (Listed accordingly) raceways and suitable for use and location.
1. EMT: Comply with NEMA FB 2.10 and with requirements of these specifications.
  2. GRC/RMC and IMC: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

**3.2 INSTALLATION**

- A. General Installation.
1. Minimum Raceway Size: 3/4-inch trade size.
  2. Install wire in raceway/conduit unless specifically permitted otherwise elsewhere in Division 26 sections, or on drawings.
  3. Layout and install all electrical work in strict compliance with Chapter 1, Part B, Section 110.26 of the latest adopted edition of NFPA 70. Locations and routing that may be shown on plans are schematic and diagrammatic in nature.
  4. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for Conduits and raceways required by NFPA 70 as a minimum.
  5. Layout all proposed raceway routing, elevations, installation methods, etc. on coordination drawings and coordinate all proposed raceway routing with all affected trades prior to commencing with work. In addition, review the information with Owner and Design Professionals for all areas where the raceways will be visible after completion of construction, to ensure a neatly organized installation occurs. Where raceways must be exposed in finished/regularly occupied areas, install them in a manner that minimizes detrimental effects on room aesthetics. Install so raceways are as out of site as reasonably possible. For instance, where applicable for exposed work and if so directed by the Design Professionals or the Owner, make drops near corners, window casings, door casings, etc. Likewise, if a receptacle needs to be installed at the center of a wall, install the raceway down the wall in a corner of the room then transition and run



horizontally to the outlet location if so directed by the Design Professional or the Owner. Use compression fittings for EMT applications in these areas. Do not use strut or fasteners that stand off from wall for wall applications in these areas. Install exposed wall-mounted conduits tight to wall using one-hole straps for conduits 1-1/4 inches and smaller, and use two-hole straps for conduits 1-1/2 inches and larger.

6. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
7. Do not install aluminum products in contact with, or near proximity to, concrete or earth.
8. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.
9. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter.
10. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
11. Locate all structural elements within concrete prior to pre-drilling anchors. Contractor is responsible for repairing all damage to structural elements resulting from the scope of this work.
12. Provide fittings as needed for a complete installation. Provide locknuts for securing conduit to enclosures with ridged outside circumference for proper fastening. Provide miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that are specifically designed and intended for their particular application.
13. Provide knockout closures to cap unused knockout holes where blanks have been removed.
14. Provide flexible connections or expansion fittings where all conduits cross building expansion joints. Coordinate exact quantity & location with Architectural plans prior to installation of work.
15. Install electrical boxes in those locations that ensure accessibility to enclosed electrical wiring.
16. Do not install boxes back-to-back in walls. Provide not less than 6" (150 mm) separation in general, not less than 16" separation for acoustically rated walls and not less than 24" separation for the following applications: fire walls, fire barriers, smoke barrier walls, and fire partitions. Where outlet boxes are shown back-to-back on common walls, offset accordingly when installed.
17. Fire walls, fire barriers, smoke barrier walls and fire partitions: Steel outlet boxes that do not exceed 16 square inches in area may be used in fire walls, fire barriers, smoke barrier walls, and fire partitions only if the total area of such openings does not exceed 100 square inches for any 100 square feet of wall area. Verify with local authorities having jurisdiction prior to commencing with related rough-in work. Provide outlet boxes, equipment back-boxes, etc. in fire walls, fire barriers, smoke barrier walls, and fire partitions that are of the type tested for use in fire-resistance-rated assemblies. Install in accordance with the tested assembly, and with the instructions included in the listing. Install firestopping at penetrations of fire-rated floor and wall assemblies.
18. Neatly cut openings for boxes so that standard size (not "midway" or "jumbo") cover plates will cover all parts of the opening. Position recessed outlet boxes accurately to allow for surface finish thickness. Do not use round boxes.
19. Fasten electrical boxes firmly and rigidly to substrates and structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry as applicable. Provide box supports that are independent of conduit. Protect boxes from construction debris and damage subsequent to installation of boxes.
20. Use of synthetic or plastic "tie-wraps", "zip ties", "wire ties" and similar products are not permitted as a permanent means of anchoring, securing, supporting or otherwise installing any cables, conductors, conduits, raceways, devices, equipment or other electrical work. Do not use perforated straps.
21. Consider the outlet, junction, and pull box locations indicated on drawings approximate unless there are prevailing codes that require specific spacings or locations. Study the



- general construction with relation to spaces and equipment surrounding each outlet, and neatly install outlets accordingly.
22. Install wiring for different power voltages in raceway systems separate from each other. Install wiring for the various electrical systems in raceway systems that are separate from each other.
  23. Provide steel conduit and steel fittings for indoor above-slab applications, as specified in this section.
  24. Provide conduit fittings with insulated throats. Plastic bushings may be used for conduits 2" and larger where insulated throats may not be readily available.
  25. Provide maximum of 40 percent fill for raceways, or a threshold of less if required by NFPA 70 or project conditions.
  26. Keep raceways at least 12 inches away from parallel runs of flues, hot-water pipes, and other sources of heat. Install horizontal raceway runs above liquid and steam piping. Where the lines are not insulated, the clearances shall be increased until the temperature of the conduit, with no live conductors enclosed, does not rise above the ambient temperature of the installation area.
  27. Support risers at each floor level with suitable hangers.
  28. Level and square raceway runs, and install at proper elevations and heights.
  29. Protect coatings, finishes, and cabinets from damage and deterioration. Repair damage to galvanized finishes with zinc-rich paint or coating, color to match surface, recommended by manufacturer. Make these repairs prior to products receiving finish coats of paint.
  30. Pathway Evacuation and Protection: Cap and plug conduit ends with standard accessories as soon as conduit has been permanently installed. Prior to the installation of cable, clean and vacuum boxes, conduits/raceways, supports, etc. Clean inside of conduit before wiring is pulled. Remove solids or other hindrances that could impede its full utilization or that could damage cable during or after installation. Remove liquid and moisture from the raceways. Blow out until raceway is dry, sufficiently that the installed cables will not be subjected to any contact with fluid or moisture. Seal and protect raceways and boxes from moisture infiltration. Provide watertight fittings. Do not begin installation of conductors and cables until electrical raceways are complete and until installation locations (end to end) are in a weatherproof environment.
  31. Arrange stub-ups so curved portions of bends are not visible above finished grade or slab.
  32. Install no more than the equivalent of three 90-degree bends in any conduit run. Support within 12 inches of changes in direction.
  33. Support conduit within 12 inches of enclosures to which attached. Properly support and anchor raceways for their entire length using structural materials. Do not span any space unsupported.
  34. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
  35. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits. Fasten conduit terminations in sheet metal enclosures with two locknuts. Install locknuts inside and outside enclosure.
  36. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
  37. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
  38. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Cut conduits

- straight, properly ream, and cut threads for heavy wall conduit deep and clean. Field-bend conduits with benders designed for purpose so as not to distort, nor vary, internal diameters. Bring joints to a shoulder. Provide suitable supports and fasteners for conduit.
39. Conceal conduit and tubing within finished walls, ceilings, and floor cavities unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
  40. Install exposed conduits, and extensions from concealed conduit systems, neatly parallel and perpendicular to walls, and plumb on walls. Secure to walls at intervals not exceeding six feet, supported by approved straps and fasteners. Secure to overhead structure at intervals not exceeding six feet. Support conduit by approved straps, fasteners and hangers. Provide hangers suspended from rods. Space wall brackets supporting conduits not more than 4 feet 6 inches on center. Install exposed conduit work so there is no interference with ceiling inserts, lights, or ventilation ducts or outlets.
  41. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use, using properly selected and attached manufactured cap (tape of any sort is not permissible). Provide finished wall/cover plate on unused outlet boxes.
  42. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
  43. Mount boxes at heights indicated on Drawings and elsewhere in Division 26 specifications. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated. In cases where using center of box for measurement would result in a switch-height device having an operable component higher than 48 inches above finished floor, install boxes lower as needed so that uppermost part of operable component is no higher than 48 inches.
  44. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block (do not over-cut), and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
  45. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel. Coordinate all such separations with Design Professional in advance to ensure boxes are located properly for each application.
  46. Locate boxes so that cover or plate will not span different building finishes.
  47. Support boxes from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
  48. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
  49. Provide properly wired electrical connections within enclosures. Anchor enclosures ensuring that they are level, and permanently and mechanically secure.
  50. Provide conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for applications as needed to render electrical work fully operational.
  51. Mechanically fasten together metal conduits, enclosures, and raceways to form continuous electrically conducting equipment grounding path. Connect to electrical boxes, fittings and cabinets to provide electrical continuity and firm mechanical assembly. Conduit shall be continuous between outlets to make a complete installation and to provide a continuous ground.
  52. Do not use dissimilar metals throughout the systems to eliminate possibility of electrolysis. Where dissimilar metals will be unavoidably in contact, coat surfaces with corrosion inhibiting compound before assembling.

53. Use rough-in dimensions of electrically operated equipment furnished by equipment installer. Install conduit and boxes for connection to equipment only after reviewing respective equipment and clearance dimensions, and after coordinating with other trades.
54. Do not use electrical "handy/handee" boxes.
55. Do not use running threads at conduit joints and terminations - use 3-piece union, or split coupling.
56. Provide joints made tight with water-tight couplings matching conduit. Install offsets with long radius sweep bends, except conduit sizes 1 inch and over where standard elbows may be used.
57. Where moisture conditions within conduits are encountered above grade, drill a hole at the lowest point in the conduit run so that drainage will not interfere with conditions below.
58. Where conduit is capped at wall for future additions, do not extend more than threads-length past wall (maximum of 3/4-inch past wall for EMT).
59. Where conduits for outlets on waterproof walls must be installed exposed, set anchors for supporting conduit on waterproof wall in waterproof cement.
60. Requirements for exposed conduits also apply to conduits installed in space above hung ceilings, and in crawl spaces.
61. Provide a 4-inch reinforced casing of concrete (3000-PSI minimum) around conduits that are installed in cinders or cinder concrete, to protect them.
62. Support raceway components directly from structural building systems, not from ceiling suspensions systems. Provide supplemental supports for junction or pull boxes.
63. Support single conduits 1-1/2 inches and larger by means of rod and ring hangers. Support multiple runs in similar manner or use a common trapeze hanger system.
64. Pinch type hangers similar to Minerallac may only be used at heights greater than 8 feet, and only in unfinished areas where the work could be installed concealed.
65. Protect conduits during construction with temporary plugs or caps. Securely cap conduits until pull string, or cable is installed.
66. Conduit Routing: If specific routing information appears on the Drawings, route and maintain conduits as shown. Should interference or a conflict arise, consult the Design Professional before proceeding with the Work. If specific routing information does not appear on the Drawings, or if routing shown on Drawings is schematic in nature, determine the best route for the conduit in accordance with code and other project guidelines.
67. Conduit bends: Bends shall be made so that the conduit will not be flattened or kinked and so that the internal diameter of the conduit is not reduced. The radius of the curve of the inner edge of any bend shall not be less than indicated by the National Electrical Code and TIA/EIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces. In no case shall any conduit be bent or shall any fabricated elbow be applied to a conduit that will impose less than the minimum allowable bending radius specified by the manufacturer of cable that will be installed within the conduit. When it is necessary to make field bends, use tools manufactured for conduit bending. Heating of metallic conduit to facilitate bending is not permitted. Constructing an outside entrance to a building from buried conduit to penetrate above the ceiling line will allow an exception for a 4 inches LB fitting at one end to allow placement of the conduit flat to the building outside wall; apply this only if conduit could not be concealed.
68. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
69. Install above-ceiling conduits as high as possible, with a minimum of 8 inches above ceiling tiles so as to permit ceiling tile removal.
70. Provide flashing and counter flashing or pitch pockets for waterproofing of raceways, outlets and fittings that must penetrate the roof. Coordinate all related work with roofing installer and provide means and methods based on roofing installers recommendations.

71. Provide sleeves and sleeve seals at penetrations of exterior floor and wall assemblies, at penetrations of abutted perimeter walls for building expansions/additions, and where expansion joints are used at walls. Provide oversized sleeves in forms for new concrete walls, floor slabs, and partitions to allow for the passage of raceways. Provide waterproof sleeved raceways below grade and in areas prone to high moisture and condensation. Provide sleeves in member for conduits passing through structural members.
  72. Install each branch of power in separate raceways from each other.
  73. Do not install conduit horizontally in concrete slabs on grade. Do not install or embed conduits horizontally within any other slabs.
  74. Do not install branch circuit conduits beneath slabs on grade, except where specifically indicated otherwise on drawings, or unless special case by case permission is obtained from Owner's Representative in the field.
- B. Stub-ups To Above Accessible Ceilings (TAAC):
1. Use EMT, IMC, or GRC/RMC for raceways as applicable for respective locations.
  2. Provide sweep bends and drag line for each application.
  3. Use a conduit bushing or insulated-throat fitting to terminate stub-ups.
  4. Extend conduits to joist space above an accessible ceiling system.
  5. Permanently identify the purpose of the conduit stub at the end of the conduit above the ceiling.
- C. Pull Boxes and Junction Boxes:
1. Provide each pull box indicated on the Drawings.
  2. Provide additional pull boxes: Every 180 degrees of raceway bend; Every 100 feet of raceway; As additionally required by Code.
  3. Provide pull and junction boxes in areas that will be accessible after installation. Accessible areas include spaces above removable tile ceilings and behind access doors that are installed expressly for this purpose. Do not install pull-boxes in locations that will not be accessible after construction is complete and is not accessible after permanently installed work is complete.
  4. Size boxes in accordance with the NFPA 70 (NEC). Use larger boxes where so specified.
  5. Support boxes rigidly. Land conduits on the boxes so that conduits enter and exit across from each other on opposite sides of the box so as to facilitate straight line pulling of cable through the box. Do not use pull boxes in lieu of conduit bends, except as necessary by design or to meet constructability constraints.
  6. When directional transition of the cables is necessary through a box, land conduits on the box so that they permit the largest possible bending radius for those cables that will pass through the box.
  7. Coordinate all work with all other trades prior to commencement of the work. Do not use access doors unless special prior written permission is granted from the Owner's Representative. Install pull boxes, junction boxes, etc. in areas that are accessible after construction. Do not install pull boxes or junction boxes above gypsum board, plaster or similar ceiling systems, nor above ductwork or equipment that renders them inaccessible.
  8. Record junction and pull boxes on record drawings. Permanently mark and label (using methods approved by Owner's Representative) junction/pullboxes as to which types of electrical services are within.
- D. Repair and Patching: Holes and other penetrations into building surfaces or structure that are created to facilitate pathway installation but that are not ultimately used shall be filled, repaired, and restored to their original strength, appearance and integrity. Damage to building or property that occurs during the course of pathway installation shall be repaired and restored to its original condition prior to damage. Obtain review and approval of penetration sizes, means and

methods from Design Professional and Owner's Representative for all proposed penetrations of structural elements prior to commencing with any related work.

- E. **Cover Plates:** Provide gasketed stainless steel or post-fabrication hot-dipped galvanized steel cover plates over the openings of junction boxes and pull boxes. Provide blank wall plates for unused wall outlet openings, to match style and finish used for active wiring device locations in the same respective area.
- F. **Seals for Common Conduit and Raceways in Dissimilar Environments:** Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points: Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces; Where an underground service raceway enters a building or structure; Where otherwise required by NFPA 70.
- G. **Insulation for Common Conduit and Raceways in Dissimilar Environments:** Provide insulation on the exterior of conduit on the warm side of penetrations between dissimilar environments to prevent condensation from forming. Insulate with 1.5-inch polyisocyanurate closed cell pipe insulation with an overall PVC jacket for a minimum distance of 48" from the penetration. Applications include, but are not limited to, the following: Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces; Where otherwise required by NFPA 70.
- H. **Flexible Conduit Connections:** Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, for equipment subject to vibration, noise transmission, or movement, and for transformers and motors. Use LFMC in damp or wet locations.
- I. **Expansion-Joint Fittings:**
  - 1. Provide UL listed and labeled expansion fittings and appropriate couplings in metal raceways wherever structural expansion joints are crossed, wherever deflection is expected, where environmental temperature change may exceed 100 deg F with straight-run lengths that exceeds 100 feet, and as otherwise required to accommodate similar movement. Provide expansion fittings with ground bonding jumpers that are long enough to accommodate respective expansions and movement.
  - 2. Provide expansion fittings with ground bonding jumpers that are long enough to accommodate respective expansions and movement. Install in each run of aboveground EMT, GRC/RMC and IMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
  - 3. Install type and quantity of fittings that accommodate temperature changes of 155 deg F.
  - 4. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
  - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
  - 6. Type LFMC conduit may be used instead of expansion fittings in unfinished areas, using lengths of at least two (2) feet and no more than six (6) feet. Provide bonding jumpers.

7. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits.

**END OF SECTION 26 0533**



**SECTION 26 0923****LIGHTING CONTROL DEVICES****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For equipment, materials and systems specified in this section. Include product data, descriptive information, technical data, wiring diagrams, load restrictions, etc.
- A. Shop Drawings
  - 1. Submit lighting control drawings with actual occupancy/ vacancy sensor quantities, types, locations and coverage patterns as needed to provide fully operational coverage for each affected area.

**PART 2 - PRODUCTS****2.1 MANUAL LIGHTING CONTROL DEVICES – SEE SECTION 262726.00****2.2 OCCUPANCY SENSORS**

- A. General
  - 1. Provide labor, materials, tools, appliances, control hardware, sensor, wire, junction boxes and equipment necessary for and incidental to the delivery, installation and furnishing of completely operational occupancy sensor lighting controls, as described herein.
  - 2. Provide products supplied from a single manufacturer that has been continuously involved in manufacturing of occupancy sensors for a minimum of five (5) years.
  - 3. Provide occupancy sensors for entire project that are all made by the same manufacturer, regardless of where the materials are specified in Division 26 documents. Provide components that are all made by the same manufacturer in cases where occupancy sensor components are also connected to a building lighting control system, regardless of where the materials are specified in Division 26 documents.
  - 4. Provide components that are U.L. listed, offer a five (5) year warranty and meet state and local applicable code requirements.
  - 5. Provide products manufactured by an ISO 9002 certified manufacturing facility with a defect rate of less than one-third of one percent.
  - 6. Provide sensors capable of operating normally with LED Drivers, electronic ballasts, PL lamp systems and rated motor loads.
  - 7. Provide sensors with coverage that remains constant after sensitivity control has been set. Automatic reduction in coverage due to the cycling of air conditioner or heating fans is not permitted.
  - 8. Provide sensors with readily accessible, user adjustable settings for time delay and sensitivity. Locate settings on the sensor (not the control unit) and recess to limit tampering.
  - 9. Provide bypass manual override on each sensor to accommodate failures. Configure so that when bypass is utilized, lighting remains on constantly or control diverts to a wall switch until sensor is replaced. Recess this control to prevent tampering.



10. Provide sensors with an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
  11. Where specified, provide sensor with internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options. Do not use sensors that utilize separate components or specially modified units to achieve this function.
  12. Provide sensors with UL rated, 94V-0 plastic enclosures.
- B. Acceptable Manufacturers: Subject to being equivalent and subject to compliance with requirements, provide product by one of the manufacturers listed below. If not listed, submit as substitution.
1. Cooper Greengate CA
  2. Hubbell
  3. LC&D
  4. Leviton
  5. Lutron
  6. Sensor Switch
  7. Phillips
  8. Wattstopper
- C. Dual technology sensors: Provide sensors that are either wall mounted, corner mounted or ceiling mounted in such a way as to minimize coverage in unwanted areas. Provide passive infrared and ultrasonic or microphonic technologies for occupancy detection.
- D. Ceiling Sensors: Provide Standard of Quality equal to WattStopper: WT-605, WT-600, WT-1105, WT-1100, WT-2205, WT-2200, WT-2250, WT-2255, WP-605, WP-1105, WP-2255, WP-2205, W-500A, W-1000A, W-2000A, W-2000H, UT-300, UT-305, UT-355, WPIR, HB-100, HB-150, DT-200, DT-205, DT-300, DT-305, DT-355, CX-100, CX-105, CI-200, CI-205, CI-300, CI-305, CI-355, CI-12 or CI-24 series.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Installation: Provide grounded ("neutral") conductor in all lighting control device (switch, dimmer, occupancy sensor, etc.) wall outlet boxes, even if not immediately used.
- B. Occupancy Sensors
1. Locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Provide ninety (90) to one hundred (100) percent coverage in rooms to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the rooms. The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. Provide additional sensors if required to properly and completely cover the respective room.
  2. Arrange a pre-installation meeting with manufacturer's factory authorized representative, at Owner's facility, to verify placement of sensors and installation criteria.

3. Exercise proper judgment in executing the installation to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components.
4. Provide, at the Owner's facility, the training necessary to familiarize the Owner's personnel with the operation, use, adjustment, and problem solving diagnosis of the occupancy sensing controls.
5. Upon completion of the installation, provide complete commissioning for controls by the manufacturer's factory authorized technician who will verify adjustments and sensor placement to ensure trouble-free occupancy-based lighting controls. Provide the Owner and Design Professionals with ten working days written notice of the scheduled commissioning date. Upon completion of related work, including fine tuning, provide factory authorized technician training to the Owner's personnel in the adjustment and maintenance of the sensors.

**END OF SECTION 26 0923**

**SECTION 26 2726 - WIRING DEVICES****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For each type include electrical characteristics, configurations, ratings, markings, colors, etc.

**1.2 GENERAL**

- A. Information regarding the following is included in other Division 26 specification sections and/or on drawings: weatherproof cover plates, special identification requirements, and occupancy sensors.
- B. Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. Verify color selections with Owner's Representative.
- C. Coordination: Receptacles for Owner-Furnished Equipment: Match plug configurations. Cord and Plug Sets: Match equipment requirements.
- D. Definitions:
  - 1. EMI: Electromagnetic interference.
  - 2. GFCI: Ground-fault circuit interrupter.
  - 3. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
  - 4. RFI: Radio-frequency interference.
  - 5. SPD: Surge protection device.
  - 6. Tamper-resistant: This term and "safety type" shall be taken to mean the same thing for receptacles.

**PART 2 - PRODUCTS****2.1 GENERAL**

- A. Acceptable Manufacturers: Subject to being equivalent and subject to compliance with requirements, provide product by one of the manufacturers listed below.
  - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper)
  - 2. FSR Inc. (FSR)
  - 3. Hubbell Incorporated (Hubbell)
  - 4. Hubbell Incorporated; Wiring Device-Kellems (Hubbell)
  - 5. Hubbell Incorporated; Wiring Device-Bryant (Hubbell)
  - 6. Legrand
  - 7. Leviton Mfg. Company Inc. (Leviton)
  - 8. Lutron Electronics, Inc. (Lutron)
  - 9. Pass & Seymour/Legrand (Pass & Seymour)

10. Wiremold/Legrand (Wiremold)

- B. For receptacle circuits protected with 15A breakers, provide NEMA 5-15R equivalents for the devices specified in this section.
- C. Provide equivalent quality devices by manufacturers listed in subparagraphs hereafter for cases where voltage, amperage and/or NEMA configurations that are indicated on drawings or, are otherwise required based on project conditions, differ from those specified herein.
- D. Provide Weather-Resistant Receptacles with UL "WR" marking, compliant with NEC 406.8, for all applications in wet or damp locations.
- E. Where GFI protected receptacles are shown on drawings, provide a separate GFI receptacle for each one shown. Do not feed downstream receptacles from load-side (GFI-protected) terminals of upstream receptacles.
- F. Provide corrosion-resistant versions of receptacles specified below for industrial applications and applications in corrosive or potentially-corrosive environments.
- G. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions: Connectors shall comply with UL 2459 and shall be made with stranding building wire; connectors are NRTL listed for intended use; connectors comply with the requirements in this Section; connectors are permitted by Authorities Having Jurisdiction.

## **2.2 STRAIGHT-BLADE RECEPTACLES**

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R (20A) or 5-15R (15A), UL 498, and FS W-C-596. Provide duplex and single specification grade receptacles, 2-pole, 3-wire grounding, self-grounding, green grounding screw, ground terminals and poles internally connected to mounting yoke, color coded base, 20-amperes, 125-volts, with metal plaster ears, back & side wiring, NEMA configuration 5-20R. Subject to compliance with requirements, provide one of the following (catalog numbers in subparagraphs below are for 20-A, heavy-duty, specification-grade, nylon-face devices; revise catalog numbers to require other configurations and ratings):
  - 1. Cooper; 5351 (single), CR5362 (duplex)
  - 2. Hubbell; HBL5351 (single), HBL5352 (duplex)
  - 3. Bryant; 5351 (single), 5352A (duplex)
  - 4. Leviton; 5351 (single), 5362 (duplex)
  - 5. Pass & Seymour; 5351 (single), 5362 (duplex)

## **2.3 COMMUNICATION, INFORMATION TECHNOLOGY AND SIMILAR OUTLETS**

- A. Provide the following for communication, information technology and similar outlets that are shown on electrical drawings.
  - 1. Provide 4-inch square by minimum 2-1/8 inch deep outlet box with single-gang ring.
  - 2. Provide single-gang blank wall plate of material and color to match wiring devices in the respective room/area.

3. Provide at least one 3/4" empty conduit from outlet box to accessible ceiling cavity, or to overhead joist/structure space in areas with no finished ceilings. Provide sweep bends and insulated throat fittings (or plastic bushings) at each end of the conduit
4. Provide 200-pound pull string within conduits, easily accessible at both ends.
5. Provide neat permanent marking at the end of the overhead stub that clearly states the purpose of the conduit and the room where the respective outlet is located.
6. Coordinate all locations, heights and other specifics with the respective device/system installers and provide all work accordingly.

## **2.4 WALL PLATES**

- A. Single and combination types shall match corresponding wiring devices. Provide metal plate-securing screws with head color to match plate finish. Provide factory markings on faces of receptacles that are controlled for energy management or building automation that are compliant with Article 406.3(E), including symbol and the word "Controlled". Provide engraved wall plates where required by prevailing codes, indicated on drawings or indicated in Division 26 specifications.
  1. Material for Finished Spaces: satin finish stainless steel, equal to Leviton Type 430 series
  2. Material for Unfinished Spaces with surface-mounted outlet boxes: Galvanized steel
  3. Material for Indoor Damp Locations: Gasketed satin finish stainless steel, equal to Leviton Type 430 series, with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant. Refer to Section 26 05 33.00.

## **2.5 FINISHES AND INDICATORS**

- A. Device Color (unless otherwise indicated or required by NFPA 70 or device listing):
  1. General Wiring Devices Connected to Normal-Utility Branch of Power System: White.
- B. Wall Plate Color: For plastic covers, match device color.
- C. Illuminated Indication: Provide illuminated face or indicator light versions of wiring devices specified herein where indicated as such on drawings and/or where required by prevailing code(s), to indicate that there is power to the device.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Coordination with Other Trades: Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall. Install wiring devices after all wall preparation, including painting, is complete.

- B. Conductors: Provide grounded ("neutral") conductor in all lighting control device (switch, dimmer, occupancy sensor, etc.) wall outlet boxes, even if not immediately used. Do not strip insulation from conductors until right before they are spliced or terminated on devices. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails. Existing Conductors: Cut back and pigtail, or replace all damaged conductors; Straighten conductors that remain and remove corrosion and foreign matter; Pigtailing existing conductors is permitted, provided the outlet box is large enough.
- C. Device Installation:
1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
  2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
  4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
  5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
  6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
  7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
  8. Tighten unused terminal screws on the device.
  9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
  10. Install wiring devices only in electrical boxes that are clean; free from building materials, dirt, and debris. Install wiring devices after wiring work is completed. Install wall plates only after respective wall surfaces have received their final finish.
  11. Consider locations indicated on the drawings to be approximate (unless specifically dimensioned on drawings, or unless spacings must comply with prevailing codes). Study the general construction with relation to spaces and equipment surrounding each outlet.
  12. Do not use aluminum products in concrete.
  13. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry. Support boxes independent of conduit.
  14. Provide feed-through-type GFCI receptacles where downstream receptacles are fed from the line side of the GFCI receptacle.
  15. Adjust locations of outlets, devices, etc. to suit arrangement of partitions and furnishings.
  16. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates
  17. Receptacle Orientation: Install receptacles so that the ground pin is oriented in a consistent manner throughout the facility, so that the orientation is compliant with all prevailing codes and regulations, and so that the orientation is acceptable to the electrical inspector. Where there is no existing building standard or other project requirement, install receptacles with ground pin up. Where receptacles are installed horizontally, install so that neutral connection faces up. Coordinate with AHJ and Owner.
  18. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

**3.2 FIELD QUALITY CONTROL**

- A. Tests for Receptacles:
1. Line Voltage (120V): Acceptable range is 105 to 132 V.
  2. Test for correct polarity and grounding.
  3. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
  4. Ground Impedance: Values of up to 2 ohms are acceptable.
  5. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  6. Using the test plug, verify that the device and its outlet box are securely mounted.
  7. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- B. Installed equipment will be considered defective if it does not pass tests and inspections. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

**END OF SECTION 26 2726**



**SECTION 26 5100****LIGHTING****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For each type include detailed product information, light source, color temperature, color rendering index, lumen outputs, life, driver manufacturer, model and type, ceiling connection details, integral controls as applicable, drawings of custom fixtures or components, wiring diagrams, warranty, etc. Arrange luminaire submittals in booklet form with separate sheets for each luminaire, assembled by luminaire "type" in alphabetical order.

**1.2 GENERAL**

- A. Provide all labor, materials, equipment, equipment, programming, services, etc. as required for complete and fully operational lighting and lighting control systems.
- B. Definitions:
  - 1. CCT: Correlated color temperature.
  - 2. CRI: Color-rendering index.
  - 3. LER: Luminaire efficacy rating.
  - 4. Lumen: Measured output of lighting source, luminaire, or both.
  - 5. Luminaire: Complete lighting unit consisting of lighting source or sources, and some or all of the following components as applicable: optical control devices, contacts, mechanical components to support or attach the luminaire, and electrical and electronic components to start, operate, dim or control and maintain the operation of lighting source, and driving and transformation components.
  - 6. Lighting Source: LED boards or equivalent LED assembly.
  - 7. THD: Total harmonic distortion

**1.3 QUALITY ASSURANCE**

- A. Obtain equipment and components from single manufacturer for luminaires of the same type and "family" style. Drawings indicate dimensions for typical equipment configurations including clearances between equipment and adjacent surfaces and other items. Ensure product complies with the layouts indicated in the drawings. Provide Components, Devices, and Accessories that are listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

**PART 2 - PRODUCTS****2.1 GENERAL REQUIREMENTS FOR LUMINAIRES AND COMPONENTS**

- A. Products: Subject to compliance with requirements, provide products indicated on Drawings. Provide products of one of the manufacturers listed in this section for products that are not defined on the Luminaire Schedule. Provide specification grade luminaires that comply with minimum requirements as stated therein. If a particular "type" does not include basis of design manufacturer or model number, provide "pre-approved equivalent" manufacturer's and model numbers compliant with, and equivalent to: quality, performance, dimensions, and aesthetics as the respective basis of design for Design Professional review no less than five business days prior to bid due date.
- B. Luminaires designated by letters are defined as indicated on the Luminaire Schedule.
- C. Provide luminaires, of sizes, types and ratings indicated; complete with, but not limited to, housings, energy-efficient light sources, contacts, reflectors, wiring, etc. Ship luminaires factory-assembled, with components required for a complete operating installation.
- D. Recessed Luminaires:
  - 1. Comply with NEMA LE 4 for ceiling compatibility for recessed luminaires.
  - 2. Provide recessed luminaires with necessary gypsum board, plaster frames, and surface trim.
  - 3. Provide recessed luminaires that are constructed without rolled edges and that are post-painted.
  - 4. Provide door frames on troffer style luminaires with spring latches on door frames.
  - 5. Provide static air function for luminaires unless otherwise noted.
  - 6. Provide luminaires that are non-IC constructed unless otherwise noted.
  - 7. Provide junction boxes and serviceable components (driving and transformation component types, thermal protection devices, fuses, etc.) for recessed luminaires that are accessible for service and replacement from below the ceiling, without removing ceiling components.
  - 8. Where plaster frames are inferred for luminaires (either by narrative, or by catalog number, or by application) interpret the actual function to mean for mounting within gypsum board, wet plaster or similar type inaccessible ceiling system. Field verify related requirements and provide required accessories, such as frames, accordingly.
  - 9. Provide UL approved (listed and labeled) thermal protection per latest edition of NFPA/NEC for recess mounted luminaires.
- E. Surface Luminaires: Install surface mounted luminaires with air spaces between luminaire and surface per latest edition of NFPA/NEC. Provide factory luminaire wiring that is per NEC, #16 AWG minimum. Wire luminaires in accordance with the latest requirements of the National Electric Code.
- F. Review drawings and specifications of other trades to verify ceiling types, modules, and suspension systems appropriate to installation.
- G. Luminaires: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5, 5A, 5B, etc. as applicable.

- H. Metal Parts: Free of burrs and sharp corners and edges.
- I. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- J. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit replacing lighting source(s) without use of tools. Design to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during servicing and when secured in operating position. Fabricate luminaires with concealed hinges and catches, with metal parts grounded as common unit, and so constructed as to dampen generated noise.
- K. Diffusers and Globes: Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation, UV stabilized. Provide at least 0.125 inch minimum lens thickness unless otherwise indicated. Glass: Annealed crystal glass unless otherwise indicated.
- L. Factory-Applied Labels: Comply with UL 1598. Include recommended lighting sources, and driving and transformation components. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lighting sources are in place.
  - 1. Label shall include the following characteristics:
    - a. "USE ONLY" and include specific component type.
    - b. CCT and CRI for all luminaires.

## **2.2 EMERGENCY LED POWER UNIT**

- A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with light source driver(s)/board(s). Install remote from luminaire if so indicated on drawings, at accessible location and wired as directed by manufacturer. Comply with UL 924.
  - 1. Emergency Connection: Unless noted otherwise, operate light source continuously at full output. Connect unswitched circuit to battery-inverter unit and switched circuit, and/or control wiring as applicable, to luminaire.
  - 2. Test Push Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
    - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: Pilot LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 3. Battery: Sealed, maintenance-free, nickel-cadmium type.
  - 4. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
  - 5. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red pilot LED.
  - 6. Provide Bodine Cold-Pak series or approved equivalent. Provide with temperature-control circuitry to fulfill both low-temperature and high-temperature operation. Provide with high-temperature, maintenance-free nickel cadmium battery, charger, and electronic circuitry contained in one nominal 14" x 3" x 1-1/2" red metal case. Provide solid-state charging indicator light to monitor the charger and battery, a test switch, and installation hardware.

Provide unit capable of operating luminaire at full light output in the emergency mode for a minimum of 90 minutes. Provide unit that is suitable for use in damp locations and suitable for use in sealed & gasketed luminaires. Provide unit with storage and operating temperature range for the B50Cold-Pak of -20 degrees C to +55 degrees C. Provide unit UL listed for installation inside, on top of, or remote from the luminaire. Provide unit with full five-year warranty from the date of purchase.

## **2.3 EXIT SIGNS**

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  - 1. Lighting Source for AC Operation: LEDs, 50,000 hours minimum rated life for lighting source.

## **2.4 LIGHT EMITTING DIODE (LED) SYSTEMS**

- A. Light Emitting Diode (LED) Systems
  - 1. LED Sources: Provide factory installed LED modules that are specifically designed for, and matched and mated to, the respective luminaire in which they are used. Provide LED modules that can easily be replaced in the field and are readily accessible for replacement. Provide color temperature as indicated in Luminaire Schedule.
  - 2. LED Drivers; Provide factory installed driver(s) for the LED source utilized that are specifically coordinated to the LED source and luminaire in which they are used. Provide driver(s) having specific operating characteristics defined in the Luminaire Schedule. Provide driver(s) that can easily be replaced in the field and are readily accessible for replacement. Provide specification sheet for the specific driver as part of the Luminaire Submittal.
  - 3. Total Harmonic Distortion (THD) Rating: Less than 20 percent. Provide factory-installed integral filtering system to ensure THD does not exceed 20 percent regardless of quantities and/or mixes with other manufactured LED systems.

## **2.5 LUMINAIRE SUPPORT COMPONENTS**

- A. Support fixtures in compliance with NEC. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single luminaire. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod. Hook Hangers: Integrated assembly matched to luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.

- E. For open ceiling spaces where fixtures are suspended and subject to damage or impact, provide an additional air craft cable support securely fastened to luminaire and structure to act as a safety chain providing a redundant support. Select cable based on manufacturer's recommendations, accounting for weight of luminaire assembly, external forces that could be applied, minimum 200% factor of safety, etc. Decorative pendants in finished spaces are exempt from this requirement.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Luminaires: Set level, plumb, and square with ceilings and walls unless otherwise indicated. Install lighting sources in each luminaire.
- B. Temporary Lighting: If it is deemed necessary, and permitted by Owner's Representative and Design Professionals, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is substantially complete, remove the temporary luminaires, disassemble, clean thoroughly, install new LED boards, and reinstall.
- C. Remote Mounting of Driving and Transformation Components: Distance between the driving and transformation components and luminaire shall not exceed that recommended by the luminaire and driving and transformation components manufacturer. Verify, with manufacturers, maximum distance between driving and transformation components and luminaire.
- D. Lay-in Ceiling Luminaires Supports: Unless required otherwise under other sections or unless project requirements and conditions require otherwise, grid may be used as a support element, subject to coordinating installations with ceiling system installer to ensure the ceiling system installer accounts for the weights of each luminaire and of all luminaires collectively, and installs specially marked and designated ceiling support components.
  - 1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches from luminaire corners.
  - 2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
  - 3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- E. Suspended Luminaire Support:
  - 1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers.
  - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
  - 4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
- F. Install surface and recessed ceiling luminaires on grid and tile ceilings to agree with module of ceiling either displacing a tile, or unit on center of tile, or centered on grid lines. Install flush mounted luminaires properly to eliminate light leakage between luminaire frame and finished surface.

- G. Do not locate splice or tap within an arm, stem, or chain. Provide wiring continuous from splice in outlet box of the building wiring system to driving and transformation component terminals in luminaires.
- H. Provide Type MC Cable or wiring in minimum 1/2" diameter flexible metal conduit (with full parity sized green insulated equipment ground wire) for "drops" from building wiring system junction boxes to suspended ceiling mounted luminaires. Limit the length of these "drops" to 72". Install "drops" to luminaires in gypsum board, and similar inaccessible ceiling systems, from identified accessible junction boxes.
- I. Connect luminaires utilized for emergency egress lighting and exit signage ahead of switching and other controls. The only exceptions to this are photocell-only controls for outdoor emergency egress luminaires.
- J. Provide luminaires and luminaire outlet boxes with hangers to properly support luminaire weight. Submit design of hangers, method of fastening, other than indicated or specified herein, for review by Owner's Representative and review by ceiling installer. Anchor luminaires installed in, or on, suspended ceiling systems in strict compliance with NEC, including advance coordination with the ceiling installer. Support surface mounted luminaires greater than 2 feet in length at a point in addition to the outlet box luminaire stud. Fasten electrical luminaires and brackets securely to structural supports. Install luminaires level and plumb.
- K. Where special mounting conditions are encountered, such as mounting to rounded columns or similar special circumstances, provide special custom factory-fabricated mounting means (i.e., brackets designed to conform with curvature of rounded columns, or to conform with similar special surfaces).
- L. Provide stems and chains for luminaires as designated by the Owner's Representative where deemed necessary by the Owner's Representative to achieve a functional and neat installation. Contact Owner's Representative to determine pendant, stem, and chain lengths if mounting height is not indicated.
- M. Provide plaster frames, or gypsum board frames, or similar kits for recessed luminaires installed in other than suspended grid type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.
- N. Wear clean white cotton gloves when handling the luminaires reflective and diffusing surfaces. Clean surfaces including dust, finger prints, paint, etc. with a clean dry cheesecloth after interior work has been completed. Remove plastic shipping bags from luminaires only after work in the respective area is complete.
- O. Where applicable, verify that measured illuminance values comply with respective isolux (or equivalent) plot diagram values.
- P. Provide full assembly for luminaires that are shipped with any loose components, regardless of who furnishes the luminaires.
- Q. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to emergency source and retransfer to normal.

- R. Make adjustments and perform settings/programming to lighting controls/systems so that all luminaires are fully operational compliant with design requirements and to the satisfaction of the Owner and Design Professionals, and of requirements of authorities having jurisdiction.
- S. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark. Adjust aimable luminaires in the presence of Owner's Representative and Design Professionals.
- T. Train Owner's maintenance personnel to adjust, operate, clean, and maintain equipment, devices, controls, instrumentation, and accessories.

**END OF SECTION 26 5100**



**SECTION 26 5561****THEATRICAL LIGHTING SYSTEM AND CONTROL****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Product Data
  - 1. For each type include detailed product information, light source, color temperature, color rendering index, lumen outputs, life, driver manufacturer, model and type, ceiling connection details, integral controls as applicable, drawings of custom fixtures or components, wiring diagrams, warranty, etc. Arrange luminaire submittals in booklet form with separate sheets for each luminaire, assembled by luminaire "type" in alphabetical order. Include product data with dimensions for all system components including dimmers, controllers, receptacles, etc.
  - 2. Submit as separate submittal (PD) but at same time as Shop Drawings for this section.
- B. Shop Drawings
  - 1. Include theatrical lighting and controls layouts showing lighting locations, aiming angles, wiring diagrams, schedules, etc.
  - 2. Submit as separate submittal (SD) but at same time as Product Data for this section.
- C. Training
  - 1. Cover installation, maintenance, troubleshooting, programming, repair and operation of the system.

**1.2 GENERAL REQUIREMENTS**

- A. Specific Lighting Control Details: The drawings may or may not include system specific diagrams and details from one of the pre-approved basis of design manufacturers listed below. These details are intended to describe the intent of the system and are not a replacement for actual shop drawings and system details that shall be provided by the lighting control system manufacturer.
- B. Provide all necessary equipment, as detailed on drawings and/or schedules, for a complete theatrical lighting and control system, including theatrical luminaires, fixtures and accessories. Provide all labor, materials, equipment, equipment, programming, services, etc. as required for complete and fully operational lighting and lighting control systems. Include the services of a qualified engineer regularly employed by the manufacturer of the system who shall check the installation and ensure its proper operation. No part of the system shall be energized before being checked and tested, and the installation approved by manufacturer.
- C. Include all rigging required for mounting of the items specified within this section within the scope of work. Pipe, threaded rod, etc. shall all be included within this contract. Paint all rigging devices and supports flat black unless noted otherwise in this specification.

- D. Definitions
1. CCT: Correlated color temperature.
  2. CRI: Color-rendering index.
  3. LER: Luminaire efficacy rating.
  4. Lumen: Measured output of lamp, luminaire, or both.
  5. Luminaire: Complete lighting unit consisting of lamps or sources, and some or all of the following components: optical control devices, sockets, mechanical components to support or attach the luminaire, and electrical and electronic components to start, operate, dim or control and maintain the operation of lamps or LEDs with drivers.
  6. THD: Total harmonic distortion

### **1.3 QUALITY ASSURANCE**

- A. Obtain dimmer cabinets, dimmers, theatrical luminaires, devices, components, etc. through one source from a single manufacturer. The manufacturer shall have been producing lighting control equipment for at least ten consecutive years. In order to maintain a high standard of quality and service, the manufacturer of the complete system shall also be the manufacturer of the control and dimming components used in this system.
- B. Make ordering of new equipment for expansions, replacements, and spare parts available to end user. Make new replacement parts available for minimum of ten years from date of manufacture.
- C. The manufacturer shall warrant their equipment to be free from defects in material and workmanship for a period of 2 years after the manufacturer's checkout of the installation and Owner's acceptance of the installation. Failures include, but are not limited to, the following:
1. Software: Failure of input and output to execute control commands.
  2. Failure of modular relays to operate under manual or software commands.
  3. Driver failure.
  4. Damage of electronic components due to transient voltage surges.
- D. The manufacturer shall have been producing theatrical lighting system and control equipment and systems for at least ten consecutive years.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide theatrical lighting and control systems of one of the following. If not listed, submit as substitution. Prior approval is required for all substitution proposals. Complete catalog data, specifications, and technical information on substitution equipment must be furnished to the Design Professionals and Owner's Representative at least fourteen (14) business days in advance of the bid date. Accepted substitutions will be stated in the final addendum.
1. Strand Lighting
  2. Electronic Theatre Controls, Inc. (ETC)
  3. Leviton Theatrical Lighting Systems
  4. Lehigh

## **2.2 GENERAL**

- A. All components shall be listed by UL or equivalent independent testing laboratory acceptable to authorities having jurisdiction. Provide lugs, lug kits and related accessory work as required to accommodate the conductor sizes and quantities needed for each application. Coordinate with single-line diagram, field conditions, etc.

## **2.3 THEATRICAL LIGHTING NEWTORK**

- A. General.
  - 1. All components listed below shall be installed in existing cabinet.
- B. Components.
  - 1. The panel shall contain all necessary wiring and terminations for assembly of panel mount components, including internal power supply, plug strips, and cabling.
  - 2. Provide Wall Mounted, Locking 10U 19" Equipment Rack To Include the Following:

<u>Description</u>	<u>Base Quote Quantity</u>
Network Switch, 24 Port, POE	1
Network Patch Panel, 24 Port	1
Cable Management Panel	1
ETC Four Port Response MK2 Gateway	3

## **2.4 CONTROL CONSOLE SPECIFICATION**

- A. General
  - 1. The lighting control console shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems. The console shall be the Ion Xe as manufactured by Electronic Theatre Controls, Inc., or equal.
  - 2. The system shall provide control of either 2,048 or 12,288 outputs on a maximum of 32,768 control channels, which may be any number from 1 to 99,999. Systems that require external co-processing to control 12,288 outputs shall not be acceptable. Output shall be distributed over a 10/100 MB Ethernet network using Net3/ACN, ETCNet2, Avab and/or Artnet (multi-cast) protocols. The user shall be able to control the application of protocols at an individual address level.
  - 3. The system shall support full bi-directional RDM communication with compatible devices via Net3 DMX/RDM Gateways. RDM communication shall adhere to ANSI standard E1.20-2006 Entertainment Technology – RDM – Remote Device Management Over DMX512 Networks. Supported RDM features shall include:
    - a. Discovery and Identification of RDM capable devices
    - b. Setting of start addresses, operating modes and additional settings as exposed by connected devices and controllable via RDM
    - c. Viewing of Sensor data as provided by connected devices
    - d. Error reporting as provided by connected device
  - 4. A maximum of 10,000 cues, 1000 groups, 1000 presets, 4 x 1000 palettes (Intensity, Focus, Color and Beam), 99,999 macros, 1000 effects, 1000 curves, 1000 Color Paths and 1000 snapshots may be contained in non-volatile electronic memory and stored to an onboard solid-state hard drive or to any USB storage device.

5. Recorded cue lists may be played back simultaneously on a maximum of 200 faders. Channels shall respond to cue information by last instruction with discrete rate control provided for all cues. The console may be placed in Tracking or Cue Only mode by the user as a system default and overridden on individual record actions as required. HTP/LTP intensity flags, assert, proportional, intensity master or manual master fade control. Priority and Background Priority may be placed on each cue list. It shall also be possible for a cue list to contribute to playback background states or to withhold such contributions.
6. A Master Playback fader pair shall be provided. The fader pair may execute crossfades or all-fades, with IFCB cue level timing,
7. Fader wings (standard or motorized) provide additional playback faders (up to 200), additive or inhibitive submasters (up to 999), and grand master control. Presets and IFCB palettes may be loaded to faders for playback control, either individually or in user-defined lists. Virtual fader control is also provided.
8. A high-resolution level wheel shall be provided to control intensity for selected channels and scrolling within selected displays. Four pageable encoders shall be provided for control of non-intensity parameters. Non-intensity encoders toggle between coarse and fine control. The expand function for frame table devices shall provide a graphic representation of all images and colors in the associated device for instant selection. A graphic shutter representation shall provide additional control of shutter parameters. The display shall also provide an indication of the current value for the associated parameter, based on channel selection. A high-resolution rate wheel, which may also be used for fader paging shall be provided.
9. Control surface buttons shall be backlit. This backlighting provides indication of functional states. Backlight intensity shall be user controllable, and shall automatically dim after a defined period of inactivity.
10. Control and programming features for automated fixtures shall also include: a standard library of fixture profiles, the ability to copy and edit existing profiles and create new profiles, patch displays including channel and output addressing, 16-bit fade resolution, color characterization allowing color in up to six different color spaces.
11. System information, including playback status, live output and blind values for all record targets shall be displayed on a maximum of two external high resolution monitors, which may also be multi-touch touch-screens. Every display shall support three user-definable workspaces. Each of these workspaces shall provide individually configured frames, with size/scaling controls. Any Windows 7 compatible display may be used.
12. A context sensitive on-line Help feature shall explain and provide an example of the operation of each feature of the system. This help system shall be integrated into the on-board user manual via hyperlinks.
13. A fully integrated Virtual Media Server feature shall allow user to map images and animations to a rig array. 40 such maps may be created, each with 12 layers. System that rely on external hardware or software for this functionality shall not be acceptable.
14. User-definable, interactive displays may be created. These displays, which can be used in live and blind operating modes, allow graphical layout of channels, desk buttons and programming tools. Standard symbols are provided, and the user may import their own symbols or graphics. Each symbol may be individually defined with data feedback characteristics. Non-interactive status information, such as a mirror of other user's command lines, may also be included in the display. A graphical browser is provided for fast selection of these views. Multiple zoom factors and placements may be stored and recalled for each display.
15. A detachable alphanumeric keyboard shall be provided. The keyboard shall allow labeling of all show content. An integrated virtual alphanumeric keyboard shall also be provided.
16. Console software upgrades shall be made by the user via flash drive. It shall be possible to install software updates in all consoles, processor units and remotes from one device over the network.

17. The console operating software shall be loaded into program execution memory from the internal hard drive when the console is powered. In the event of an uncontrolled shutdown, the console shall return to its last output state when power is restored. Devices requiring a UPS to provide such protections shall not be acceptable.
18. Integrated dimmer monitoring features shall be provided to allow indication of dimming system status, error states and dimmer load monitoring. Adjustment of dimmer configuration from the console shall also be supported. Communications with the dimming system shall utilize ANSI E1.17 2006 - Entertainment Technology - Architecture for Control Networks.
19. Integrated RDM device features shall be provided. The console shall discover and patch RDM devices. The console shall monitor RDM devices to allow indication of RDM device online/offline status error states. The console shall be capable of changing settings of RDM devices such as the DMX start address. Communications with the RDM devices shall utilize ANSI E1.20 2006 – Remote Device Management.
20. Network configuration tools shall be provided from within the desk.
21. Show data may be created and modified on a personal computer, using either Windows 7 or higher or a Macintosh platform running OS 10.11 or later via a free offline editing application. The program shall run natively on Apple operating systems. Applications requiring PC emulation programs shall not be acceptable.
22. A PC, using either Windows 7 (or higher), or a Macintosh running OS 10.11 (or later) using the offline software application shall be able to connect to a control system via the network and view or modify current show data in an independent display environment, using an ETCnomad key. When connected without the key, the computer shall operate in Mirror Mode, with the device to be mirrored selectable by the user.
23. Synchronized backup shall be provided via another full console on the network, an ETCnomad/Puck, or by use of a remote processor unit. The backup console/RPU shall maintain synchronized playback with the master and shall take over control of the lighting system upon loss of communication with the master. Use of two RPUs to service and backup system output is also supported.
24. A maximum of 99 users may access and interact with show data simultaneously. Each user shall have an individual workspace. User identification may be assigned to more than one control device, allowing users to work in tandem, or allowing a designer/ALD to mirror the current display format, mode and command line of the associated programmer. Partitioned control allows discrete control of channel/parameter groupings by user. Partitioned control may be easily enabled and disabled with no need to merge show data from multiple users.
25. The system shall support up to 32 individual simultaneous Time Code inputs or Event lists using Show Control Gateways.
26. Systems that do not provide the above capabilities shall not be acceptable.

**B. Controls and Playback**

1. **Manual Control and Programming Section**
  - a. The console keyboard shall be grouped by function. Major groupings shall be record target functions, numeric keys, level assignment functions, display navigation functions and controls, as well as non-intensity parameter controls.
  - b. The command keypad shall be fully interactive with direct selects and other virtual controls, which provide “one touch” selection of channels, groups, palettes, presets, effects, snapshots and macros.
  - c. Non-intensity parameters may be set numerically via an extensible keypad. This control shall be fully interactive with the moving light encoder controls and the virtual controls. The controls shall also access available modes for each parameter type, min and max values for each parameter as applicable, as well as home position on a parameter basis. Each encoder shall support shift functions for fine

control. The range of motion of coarse control may be set by the user. Tactile feedback shall indicate full and half frame positioning of certain controls.

- d. Only those parameters available for control in the active lighting system shall be displayed for control. Displays shall condense or lowlight parameters not available to selected channels. Alternatively, the encoders may be placed in a state allowing parameters not applicable to the current selection to be suppressed.
  - e. Lamp controls provide direct access to luminaire functions such as striking and dousing arc lamps and calibrating entire fixtures or individual mechanisms of fixtures, as provided by the luminaire manufacturer. User access to these features is normalized across all manufacturers for ease of use. Use of a "control channel" for accessing these functions shall not be required and systems requiring use of control channels for these functions shall not be acceptable.
  - f. Fan functions shall be provided both via command line operation and through encoder controls.
  - g. Highlight shall be supported, with user definable highlight values. Lowlight conditions may be defined for selected, but not specified channels. Rem Dim commands, at specific levels by channel, may be optionally and automatically called with the highlight command.
  - h. Advanced color control functions provide color mixing in any of six different color spaces. Gel matches are provided via gel picker or by command line control. Tinting tools allow adjusting the color mix irrespective of the native mixing system. Spectrum tools support adjusting the output of additive color systems with more than three emitter types, allowing the X/Y coordinate to be held while adjusting the recipe that achieves that mix. Color Path tools allow the user to control the live fade of fixtures through the color space.
  - i. The Virtual Media Server function shall allow the user to create layouts of devices, identified as pixel maps. Media content (images, movies, text and procedurally generated effects) may then be applied, manipulated and stored. Stock content is provided and the user may import his own imagery and animations.
  - j. Macros may be set to run as default. Default macros called manually shall post to the command line, but executed via cue lists shall run in the background. The user may override this behavior by defining the macro to always execute in the foreground or background, regardless of the recall method. Startup, Shutdown and Disconnect macros may also be defined.
2. Playback Section
- a. The playback faders shall consist of a 100mm Master Fader pair with three control buttons.
  - b. Additional playbacks may be defined via external wings and/or virtual fader controls. Faders may be grouped for playback with user definable controls.
  - c. It shall be possible to instantaneously halt an active cue, back to the previous cue, manually override the intensity fade or manually override the entire fade.
  - d. It shall be possible for a cue list to contribute to the background state or for the contents of each cue list to be withheld from such. Priority and background priority states may be established.
  - e. Playback faders shall have the following associated controls:
    - 1) Freeze, which halts the output of the fader
    - 2) Stop Effect, which stops the action of an effect
    - 3) Filter, to assign filter states to a fader
    - 4) Go To Cue 0, to reset a cue list
    - 5) Off, to turn off the contents of a playback, releasing control to the background state or to set to null.
    - 6) Assert, to replay an active cue
    - 7) Release, to release control to the background and reset the cue list.
    - 8) Timing disable, channel filters, parameter filters, priority and background priority status may also be defined.



- 9) The potentiometer shall be configurable as a proportional master, an intensity master, or manual master. Support for rate, effect rate, effect size and Master Only controls is also provided. Filtered manual timing masters and effects masters may be configured.
  - 10) Rate override and fader paging are supported with a wheel encoder and associated controls.
3. Submasters
    - a. Up to 999 proportional, fully overlapping additive or inhibitive submasters may be defined. Submasters shall have colored LEDs to indicate submaster status. Each submaster may have fade up, dwell and down fade times. Submasters may be set to priority and background priority status.
    - b. Submasters may be set to HTP or LTP intensity. Non-intensity parameters on submasters shall be LTP only.
    - c. Exclusive mode for a submaster shall prohibit the live contribution of that submaster from storing to cues or other submasters. Shield mode prohibits access of associated channels from any other playback or manual control operations.
    - d. A submaster potentiometer may be defined as proportional, master only or intensity master. When set as an intensity master, a mark and unmark feature is supplied.
    - e. The submaster blind buffer shall be linked directly to live playback.
    - f. It shall be possible to set submaster values directly from the command line.
    - g. Submasters may be set to fade to background or to minimum value when the fader is returned toward zero.
    - h. Submaster values may contribute to the background state or withheld from such.
  4. Grand Master Faders
    - a. The location of the Grand Master shall be user definable. The grand master shall have associated blackout and blackout enable buttons.
    - b. Blackout shall send all associated intensity outputs to zero. Non-intensity outputs shall not be affected.
- C. Display Controls
1. Format shall change the view of selected displays.
  2. It shall be possible for the user to choose which parameter categories or parameters (s)he wishes to display.
  3. Flexichannel modes shall change which channels are viewed in selected displays, as follows:
    - a. No modes
    - b. Masters only/cells only
    - c. Use Partitions
  4. Flexichannel states shall change which channels are viewed in selected displays, modified by the modes, as follows:
    - a. All channels
    - b. Patched channels
    - c. Show channels
    - d. Active/Moved channels
    - e. Selected channels
    - f. Manual Channels
    - g. View channels (user identified list)
    - h. Channels with discrete timing
  5. Expand shall extend the selected view sequentially across connected displays, vertically or horizontally.
  6. Time depressed shall display discrete timing data. Data suppressed shall display absolute values of referenced data. These functions may be latched.



7. Displays may also be toggled to show stored data currently manually overridden, the source of the current parameter data, output level, patch assignment, part structure and referenced marking data.
8. Playback status displays are provided with a variety of different formats. Indications are provided per cue for live moves (lights fading from zero and also moving non-intensity parameters) and dark moves (inactive lights which have stored non-intensity parameter moves).
9. Display content including which of the workspaces is in focus on any of the two monitors and what views are docked in those workspaces may be instantly recalled using snapshots.

**D. Operating Modes**

**1. Live Mode**

- a. Channel lists may be constructed using the +, -, and Thru keys as well as the direct selects. Channel selection and deselection is fully interactive, regardless of the method used.
- b. Levels may also be set with the keypad, level wheel and non-intensity encoders. "Selected" channels shall be those last addressed and under keypad control. Controls are provided for single button access to the last selected channel list, all channels with manual levels and all active channels.
- c. Channels may be set at a user defined default level using the Level key. +% and - % keys adjust channels quickly by user definable values.
- d. Channels and/or channel parameters may be captured. Capture mode shall allow the user to selectively capture channel data at specific levels. Captured data shall be indicated on the Live display.
- e. Sneak shall be used to restore specified channels to background states, default values, or to send them to specified values, in user specified times.
- f. Selected channels may be set at a level or held to current values while all other channels are set to zero using Rem Dim. Toggling Rem Dim shall restore all unselected channels to original levels. The Rem Dim level shall be user definable via the command line or with a default setup value.
- g. Channels may be recorded into groups for fast recall of commonly used channels. 1000 groups shall be available. Groups shall store selection order. The Offset function supports rapid creation of ordered groups, including reverse and random order.
- h. Parameter settings may be stored to Intensity, Focus, Color and Beam Palettes and to Presets. All referenced data may be stored to whole numbers or to up to 99 decimal places between each whole number.
- i. The following conditions may be placed on a channel or channel parameter to be included with a cue record action.
  - 1) Discrete fade time and/or delay
  - 2) Block flag
  - 3) Assert flag
  - 4) IFCB Filters, which may be set at a parameter level.
  - 5) and Restore
- j. 999 cue lists may be stored. Cues may be recorded in any order. Up to 99 decimal cues may be inserted between any two whole number cues. Each cue may contain a maximum of twenty parts.
- k. It shall be possible to record cues and cue parts with the following information:
  - 1) Any collection of channel data, as determined by the use of "Record", "Record Only" or selective store commands, combined with parameter filters.
  - 2) Cue Level timing and delays for Intensity Up, Intensity Down, Focus, Color and Beam.

- 3) Follow or hang time
- 4) Link instruction
- 5) Loop value
- 6) Block, Assert, Preheat, and/or Mark Flag
- 7) Curve
- 8) Allfade
- 9) Label and note
- 10) Execute list to trigger other activity
- I. Non-intensity channel parameters may be marked (preset), in two ways. Automark presets any parameters transitions in the cue just prior to intensity becoming active. Automark may be disabled on a cue or cue part basis, enabling a "live" move. Alternatively, non-intensity parameters may be marked to a specific cue with a single command instruction. It shall not be necessary to store these parameters directly into the cue in which the movement is to occur.
- m. Any channel parameter may be stored with an effect instruction. These effects may contain relative offsets from current value, or absolute instructions. Effects may be progressive action or on/off states. Entry and exit behaviors shall modify the channel parameters activity when beginning and ending the effect.
- n. Update may be used to selectively add modified parameter data quickly to that parameter's current source. Update may be specified to modify referenced data content or break the link to that content. A dialogue informs the user of the content that will be updated. A trace command may be used to modify the data to the original source of its move instruction. It shall be possible to update inactive record targets.
- o. Recall From quickly pulls specified data from record targets or other channels into the current view.
- p. Copy To quickly copies selected data to specified channels or other record targets.
- q. Address and channel check functions shall be provided.
- r. Channel parameters may be "parked" at levels. Those levels are not added to any live record operations, nor may they be changed until the parked element is "unparked". Scaled park provides real time proportional adjustment of stored intensity values. Address Park shall also be provided.
- s. About shall provide detailed status of selected channels or specified record targets. This shall include current source, current value, discrete timing, parked value, marked to and for indications. Background levels and current DMX output are also displayed. Channel usage indicates submaster and cue information and also provide a "dark moves" report on a per channel basis.
- t. 1000 snapshots may be stored which instantly recall specified front panel and display configurations.
- u. Live data may be displayed in a summary view or detailed table orientation.
- v. Query shall allow selection of channels by their current or possible state. Keywords and fixture types shall allow quick access to fixtures.
- w. User definable home positions, on a per channel basis, may be defined.
- x. Channel level offset commands provide channel ordering and sub-grouping functions.
- y. Undo shall be used to sequentially step back through manual operations or to undo record and delete actions. It shall be possible to undo multiple commands in one action.
2. Blind
  - a. The Blind display allows viewing and modification of all record targets without affecting stage levels.
  - b. record target data may be displayed in a summary view, a detailed table orientation or a spreadsheet view, which allows quick data comparisons, move and replace functions.

- c. Changes to blind data shall be automatically stored. Range selection of both record targets and channels shall be supported.
  - 3. Patch Display
    - a. Patch shall be used to display and modify the system control channels with their associated library data.
    - b. Each channel may be provided with a proportional patch level, curve, label, swap and invert functions, as well as keywords to service Query.
    - c. Offset functions in patch shall allow selection of channel ranges and shall allow the user to establish a "custom" footprint for any device output.
    - d. Custom color wheels, color scrolls and gobo wheels shall be defined in patch. These devices shall be created with a simple table and graphical user interface supported by images of major manufacturers.
    - e. RDM discovery and device monitoring shall be supported.
    - f. Copy to and Move functions shall be supported in patch.
  - 4. Setup/Browser
    - a. Setup shall access system, user and device configurations.
    - b. It shall be possible to partially import Eos show files. Users shall be able to select as much or as little of the show file as required, with renumber tools.
    - c. It shall be possible to import ASCII and Lightwright data files. It shall be possible to export as ASCII or .csv.
    - d. Setup shall also access show data storage, import, export, print to .pdf and clear functions, as well as show data utilities.
    - e. The system shall support programming and playback of real time clock events, including cue, submaster and macro execution at specific times of specified days or at a time based on astronomical events.
    - f. A control screen shall be provided for network configuration, selecting date/time, software update controls, selecting functional language and/or keyboard for labeling option, as well as other system level tools.
    - g. Available languages for prompts, advisories and help messages shall include English, Bulgarian, German, Spanish, French, Italian, Japanese, Korean, Russian, Chinese, simplified and Chinese, traditional.
    - h. Supported keyboards shall include American, United Kingdom, French, German, Italian, Korean, Norwegian, Russian, Slovakian, Turkish, Swiss, Swedish, Finnish and Bulgarian.
- E. Dimmer Monitoring and Configuration
  - 1. The lighting control system shall provide communication with an ETC Sensor+, Sensor3 or FDX dimming system for remote monitoring and configuration of show specific functions from within the software application.
  - 2. Circuit level configuration and monitoring functions shall include but not be limited to:
    - a. Control mode (dimmable, switched, latch-lock, always on, off or fluorescent).
    - b. Curves
    - c. Control threshold
    - d. Min and Max Scale Voltage
    - e. Preheat
    - f. Scale load
  - 3. Rack status messages shall include but not be limited to:
    - a. State of UL924 panic closure
    - b. DMX port error/failure
    - c. Network error/failure
    - d. A, B, C Phase below 90 or above 139 volts and headroom warning
    - e. Ambient temperatures out of range
  - 4. Circuit status shall include but not be limited to:
    - a. Module type and location

- b. Output level
  - c. Control Source
  - d. Overtemp
- 5. Advanced circuit feedback shall include but not be limited to:
  - a. Load higher or lower than recorded value
  - b. DC detected on output
  - c. SCR failed on/off
  - d. Breaker trip
  - e. Module has been removed
  - f. Load failure
  - g. Shutdown due to Overtemp
- F. Interface Options
  - 1. The console shall support a variety of local interfaces.
    - a. AC input
    - b. USB (five ports for items such as alpha-numeric keyboard, mouse, touch screens, USB Flash drive)
    - c. Ethernet (two ports)
    - d. Two Display Port output connectors, supporting Windows 7 compliant monitors as 1280x1024 resolution minimum. Touchscreen/multi-touch support of any/all of these monitors is provided.
    - e. Contact Closure trigger via D-Sub connector
    - f. 4 DMX/RDM ports
    - g. Alternative Contact Closure trigger through Gateway
    - h. OSC Transmit/Receive
    - i. MIDI In/Out, MSC and MIDI Notes through Gateway
    - j. SMPTE Timecode through Gateway
- G. Accessories
  - 1. ETCPad (ETC Portable Access Device)
  - 2. iRFR and iRFR Preview (applications for iPhone, iPod Touch and iPad units)
  - 3. aRFR (application for Android devices)
  - 4. Net3 Remote Video Interface
  - 5. 20 Fader or 40 Fader non-motorized fader wings
  - 6. 0 Fader or 20 Fader motorized fader wings
  - 7. Gateways
    - a. Net3/ETCNet 2 to DMX/RDM Gateways (one to four ports)
    - b. MIDI/SMPTE Gateway
    - c. I/O Gateway with 12 analog inputs, 12 SPDT contact outputs, RS-232 interface
- H. Synchronized Backup
  - 1. An optional Backup system shall consist of one of the following combinations of devices:
    - a. Two networked Consoles.
    - b. One (or more) Console with one Remote Processor Unit (RPU)
    - c. One (or more) Consoles with two Remote Processor Units (RPUs)
    - d. ETCnomad/Puck
- I. Physical
  - 1. All operator controls and console electronics for a standard system shall be housed in a single desktop console, not to exceed 20" wide, 15" deep, 4.5" high, weighing 12.7 pounds. Console power shall be 90 – 240V AC at 50 or 60Hz, supplied via a detachable locking power cord.
  - 2. Provide the Following:

<u>Description</u>	<u>Base Quote Quantity</u>
ETC ION XE Console 2,048 Outputs	1
22" LCD Touchscreen Montior	1
25' Ethercon Extension Cable	1

## 2.5 DISTRIBUTION

- A. Wiring Devices
1. Wiring devices specified shall conform to the following standards of construction:
- B. Connector Strips
1. Each section shall consist of a 4" x 4" (102mm x 102mm) 18 gauge steel or aluminum wireway with removable cover sections for access, labeled with circuit numbers
  2. Each strip shall have a terminal compartment which shall be factory installed on the right or left end as required and shall contain molded barrier type terminals for feed connection. Knockouts, cables clamps, grid junction boxes, cable cradle, and "Kellums" cable grips shall be provided, when appropriate.
  3. Each connector strip shall be provided with 75' of Multi-Cable appropriate for number of circuits.
  4. The strip shall be provided with heavy steel mounting straps on approximately 5' (1.52m) centers, to grip up to 2" (51mm) pipe.
  5. Type S or SO, 18" (457mm) cable pigtails shall be secured by strain reliefs and shall be furnished with three pole grounded female receptacles. Flush receptacles are available in lieu of pigtails. Internal wiring shall be rated at 125 C.
  6. External finish shall be black powder coat epoxy. The entire unit shall be UL and CSA approved and labeled.
- C. Plug Boxes
1. Female receptacles shall be three pole grounded type, flush mounted.
  2. Finish shall be baked flat enamel.
  3. The unit shall be UL listed and CSA approved in Canada.
  4. The surface mounted unit shall weigh 11lbs. (5kg). The recessed unit shall weigh 9lbs. (4kg).
  5. The dimensions of the unit shall be 12" x 6" x 5" (305 x 150 x 127mm)
- D. Approved Manufacturer and Products.
1. Supply the Following:

<u>Description</u>	<u>Base Quote Quantity</u>
Ceiling Tile Mount Box with (1) 5-20 Duplex Receptacle wired to (1) 20A Constant Circuit, (2) 5-20 Duplex Receptacle wired to (2) 20A Relay Circuits, and (1) DMX Output Receptacle	6
18' 1 1/2" Schedule 40 Pipe Batten – Include All-Thread Suspension Clamps	2

## **2.6 LED ELLIPSOIDAL SPOTLIGHTS**

### **A. General**

1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource Spot, ColorSource Spot Deep Blue or ColorSource Spot Pearl as manufactured by Electronic Theatre Controls, Inc. or approved equal.
2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
3. The fixture shall be UL 1573 listed for stage and studio use
4. The fixture shall comply with the USITT DMX512-A standard
5. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage
6. ColorSource Spot and ColorSource Spot Deep Blue
  - a. The fixture shall have a LM-84 report with a L70 rating of no less than 54,000 hours
    - 1) Substitutes must provide evidence of minimum L70 rating of no less than 54,000 hours
      - a) If no LM-84 report is available, an acceptable alternate is a LM-80 report on all emitters with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report
      - b) All tests and reports must be completed by a Nationally Recognized Testing Laboratory
      - c) All tests must be conducted to IES standards

### **B. Physical**

1. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits.
2. The following shall be provided:
  - a. Lens secured with silicone shock mounts
  - b. Shutter assembly shall allow for +/-25° rotation
  - c. 20 gauge stainless steel shutters
  - d. Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement
  - e. Sturdy integral die cast gel frame holders with two accessory slots, and a top-mounted, quick release gel frame retainer
  - f. Rugged steel yoke with two mounting positions allowing 300°+ rotation of the fixture within the yoke
  - g. Positive locking, hand operated yoke clutch
  - h. Slot with sliding cover for motorized pattern devices or optional iris
3. The housing shall have a rugged black powder coat finish
  - a. White or silver/gray powder coat finishes shall be available as color options
  - b. Other powder coat color options shall be available on request
4. Power supply, cooling and electronics shall be integral to each unit.
5. The unit shall ship with:
  - a. Theatrical-style hanging yoke as standard
  - b. 5' cable with Neutrik powerCON™ to choice of connector as standard
  - c. Gate diffuser
  - d. A-size pattern holder
6. Available options shall include but not be limited to:
  - a. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
  - b. powerCON to powerCON cables for fixture power linking
  - c. Smooth Wash Diffuser for overlapping beams of light from multiple fixtures

### **C. Optical**

1. The light beam should have a 2-to-1 center-to-edge drop-off ratio
  2. The unit shall provide, but not be limited to:
    - a. Low gate and beam temperature
    - b. Sharp imaging through a three-plane shutter design
  3. The unit shall provide, but not be limited to:
    - a. 5, 10, 14, 19, 26, 36, 50, 70 and 90 degree field angles
    - b. High-quality pattern imaging
    - c. Sharp shutter cuts without halation
    - d. Shutter warping and burnout in normal use shall be unacceptable
    - e. Adjustable hard and soft beam edges
  4. 19, 26, 36, and 50 degree units shall have optional lens tubes available for precision, high-contrast imaging.
  5. Shall work with S4 LED CYC and Fresnel adapters
- D. Environmental and Agency Compliance
1. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
  2. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use
  3. The fixture shall be rated for IP-20 dry location use.
- E. Thermal
1. Fixture shall be equipped with a cooling fan.
  2. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 54,000 hours of use for color mixing versions and 36,000 hours for Pearl
    - a. Thermal management shall include multiple temperature sensors within the housing to include:
      - 1) LED array circuit board temperatures
      - 2) Fixture ambient internal temperature
  3. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.
- F. Electrical
1. The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply
  2. The fixture shall support power in and thru operation
    - a. Power in shall be via Neutrik® powerCON™ input connector
    - b. Power thru shall be via Neutrik® powerCON™ output connector
    - c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
  3. The fixture requires power from a non-dim source
  4. Fixtures shall have droop compensation to prevent thermal shift of color or intensity
  5. Power supply outputs shall have self-resetting current-limiting protection
  6. Power supply shall have power factor correction
- G. LED Emitters
1. The fixture shall contain a minimum of four different LED colors to provide color characteristics or two color temperature white LEDs for the Pearl products, as described in the Color Section below
  2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
    - a. Fixture shall utilize Luxeon® Rebel™ LED emitters
  3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.



4. LED emitters should be rated for nominal 54,000-hour L70 rating for color mixing versions and 36,000-hour L70 rating for Pearl variant
  5. LED system shall comply with all relevant patents
- H. Calibration
1. Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
    - a. Calibration data shall be stored on the control card as a permanent part of on-board operating system
    - b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
    - c. Fixtures not offering LED calibration shall not be acceptable
- I. Color
1. The fixture shall utilize an minimum of 60 LED emitters
    - a. These emitters shall be made up of Red, Green, Blue and Lime for ColorSource
    - b. These emitters shall be made up of Red, Green, Indigo and Lime for ColorSource Deep Blue
    - c. These emitters shall be made up of 2700 K and 6500 K for ColorSource Pearl
- J. Dimming
1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
  2. The fixture shall utilize an Incandescent dimming curve
  3. Dimming curve shall be optimized for smooth dimming over longer timed fades.
  4. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
  5. LED control shall be compatible with broadcast equipment in the following ways:
    - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    - b. PWM shall be capable of being set via RDM to 25,000hz
- K. Control and User interface
1. The fixture shall be USITT DMX512-A compatible via In and Thru 5-pin XLR connectors or RJ45 connectors
  2. The fixture shall be compatible with the ANSI RDM E1.20 standard
    - a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    - b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    - c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
  3. The fixture shall be equipped with a 7-segment display
  4. The fixture shall be equipped with a three-button user-interface
  5. A variable-rate strobe channel shall be provided
  6. The fixture shall offer stand-alone functionality eliminating the need for a console
    - a. Fixture shall ship with 12 preset colors or color temperatures accessible as a stand-alone feature
    - b. Fixture shall ship with 5 sequences accessible as a stand-alone feature
    - c. Each color and sequence can be modified by the end user via RDM
    - d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
      - 1) Up to 32 fixtures may be linked
    - e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming

- f. Fixtures without stand-alone operation features described above shall not be acceptable.

L. Provide the Following:

<u>Description</u>	<u>Base Quote Quantity</u>
ETC ColorSource Spot. Provide with 36° Lens Barrel, C-Clamp, Safety Cable, Power-Con to Male Edison Adapter, 6' PowerCon and DMX Combo Extension Cable	6
ETC ColorSource Engine Only. Provide with C-Clamp, Safety Cable, Power-Con to Male Edison Adapter, 6' PowerCon and DMX Combo Extension Cable	12

## 2.7 LED MOVING HEAD FIXTURES

A. Provide the Following:

<u>Description</u>	<u>Base Quote Quantity</u>
Chauvet Professional MK2 Spot. Provide with 2 C-Clamps, Safety Cable, 10' Power Con Extension Cable, 10' DMX Extension Cable and (1) Custom Glass Gobo	4

## 2.8 LED PATTERN PROJECTION LIGHTS

A. General

1. The luminaire shall be an Irideon FPZ LED ellipsoidal framing projector spotlight as manufactured by ETC, Inc., or approved equal
2. The unit shall be dimmable using ANSI 1.11 USITT DMX512-A and via local control
3. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage
4. All LED emitters must have a L70 rating of no less than 35,000 hours
  - a. Substitutes must provide evidence of minimum L70 rating of no less than 35,000 hours via a LM-80 report on all emitters
    - 1) LM-80 report must be provided with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report
    - 2) All tests and reports must be completed by a Nationally Recognized Testing Laboratory
    - 3) All tests must be conducted to IES standards

B. Physical

1. The luminaire shall be constructed of die cast aluminum, free of burrs and pits, finished in high temperature powder coat paint
  - a. Fixtures shall be available in black, white, silver and custom colors as specified
  - b. Accessories and painted parts shall be color-matched to the specified color
  - c. Non-painted parts shall be available in black, white or silver
  - d. Exceptions to color-matching shall be noted prior to custom paint approval
  - e. Shall be available with the following mounting options:

- 1) Track version shall
    - a) Have pre-installed track fitting for mounting
    - b) Provide an interface for local level control as well as DMX address setting
    - c) Be constructed of color matched plastic available in black, white or silver
    - d) Be available for use on 2-circuit DataTrack (UL markets) and 3-circuit Eutrac (CE Markets)
    - e) Fully enclose the integral LED driver
    - f) Provide an Integrated rotary level adjustment knob for local intensity control
  - 2) Portable version shall
    - a) have color-matched, pre-installed yoke box for local control and DMX input and address setting
    - b) ship with removable c-clamp for pipe mounting
    - c) have available Unistrut mounting kit
    - d) Fully enclose the integral LED driver
    - e) Provide an Integrated rotary level adjustment knob for local intensity control
  - 3) Canopy version shall
    - a) Have color-matched canopy
    - b) Ship with termination board for power and data
    - c) Offer 3 variants of control
    - d) DMX and local control
      - (A) Includes voltage barrier
        - i) DALI
        - ii) 0-10V
2. The luminaire shall:
- a. Shall utilize stainless steel shutters constructed A301 grade aluminum or better
  - b. Shall provide a lockable shutter assembly capable of +/-175-degree rotation of the framed area or pattern
  - c. Shall have a slot with a sliding cover for patterns/ gobos
  - d. Shall allow for use of E-sized metal and glass patterns
  - e. Shall include a pattern holder
  - f. Shall have an integral, magnetically held media holder for use color media, diffusion and dichroics
  - g. Shall have a thermally-insulated knobs and shutter handles
  - h. Shall have a steel yoke allowing at least 350-degree tilt of the fixture within the yoke
  - i. Shall have tool-free tilt and beam adjustment, while allowing for tool-tightening at all movement points

**C. Electrical**

1. The luminaire shall be available in 120VAC and 230/240VAC versions
2. Track version
  - a. 120V luminaries shall utilize a 2-circuit DataTrack adapter with separate neutral connections per circuit and integrated DMX data wiring. The track fitting shall be UL/ cUL LISTED, and tested to UL/cUL 1574 standards
  - b. 230V luminaires shall utilize a 3-circuit Eutrac track adapter with integrated DMX data wiring. The track fitting shall be CE marked
3. Portable version
  - a. 120V luminaries shall have 6' power cable with NEMA 5/15P connector and be UL/cUL LISTED and tested to the UL/cUL 153 standards
4. Canopy version
  - a. Shall be UL/cUL listed and tested to the UL1598 standard

- b. DMX version shall support 100V-277V
- c. DALI and 0-10V versions shall support 120V-277V

**D. Optical**

1. The luminaire shall utilize high-contrast aspheric lenses, with an anti-reflective coating to increase transmission, with:
  - a. Adjustable hard and soft beam edges
  - b. Crisp pattern imaging without significant halation
  - c. Sharp shutter cuts without halation
2. The luminaire shall utilize a lockable, three plane shutter design to provide adjustable framing angles with the ability to overlap cuts
  - a. The luminaire design shall have built-in heat dissipation to prevent shutter warping and burnout in normal use
3. The luminaire shall provide an integrated 25-50 degree zoom range
4. The luminaire shall utilize a single LED emitter and be available in configurations that include:
  - a. >80 CRI, 3000K color temperature
  - b. >90 CRI, 3000K color temperature (Gallery)
  - c. >80 CRI, 4000K color temperature
  - d. >80 CRI, 5000K color temperature
5. The LED shall be rated for an average of 70% output after 35,000 hours of use (L70 Rating)
6. The luminaire shall have an expected average power consumption of 20W maximum
7. The luminaire shall have a minimum output of 800 lumens in 80 CRI versions.

**E. Provide the Following:**

<u>Description</u>	<u>Base Quote Quantity</u>
ETC Irideon FPZ 3000 K (80+ CRI) Fixture, with 0-10V Control, Canopy Mount, and (1) Custom Glass Gobo	4

**2.9 LUMINAIRE SUPPORT COMPONENTS**

- A. Support fixtures in compliance with NEC. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers shall be 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Twin-Stem Hangers shall be two, 1/2-inch steel tubes with single canopy designed to mount a single luminaire. Finish same as luminaire. Rod Hangers shall be 3/16-inch minimum diameter, cadmium-plated, threaded steel rod. Hook Hangers shall be integrated assembly matched to luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- C. Wires for units in fully conditioned spaces shall be ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage. Wires for units in unconditioned or humid spaces shall be ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

**PART 3 - EXECUTION****3.1 INSTALLATION**

- A. Comply with installation and execution requirements set forth in Section 26 51 00.00 "Lighting". Set luminaires level, plumb, and square with ceilings and walls unless otherwise indicated. Install light sources/lamps in each luminaire. Do not use theatrical lighting as temporary construction lighting. Distance between the driver and light source shall not exceed that recommended by manufacturer. Verify, with manufacturers, maximum distance between drivers and light sources.
- B. Suspended Luminaire Supports:
  - 1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers.
  - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
  - 4. Do not acoustical tile ceiling grids as support for pendant luminaires. Support from building structure or pre-engineered theatrical lighting pipe grid system or equivalent.
- C. Do not locate splice or tap within an arm, stem, or chain. Provide wiring continuous from splice in outlet box of the building wiring system to luminaire terminals.
- D. Provide Type MC Cable or wiring in minimum 1/2" diameter flexible metal conduit (with full parity sized green insulated equipment ground wire) for "drops" from building wiring system junction boxes to ceiling mounted luminaires. Limit the length of these "drops" to 72". Install "drops" to luminaires in gypsum board, and similar inaccessible ceiling systems, from identified accessible junction boxes.
- E. Provide luminaires and luminaire outlet boxes with hangers to properly support luminaire weight. Submit design of hangers, method of fastening, other than indicated or specified herein, for review by Owner's Representative and review by ceiling installer. Anchor luminaires in strict compliance with NEC, including advance coordination with the ceiling installer. Support surface mounted luminaires greater than 2 feet in length at a point in addition to the outlet box luminaire stud.
- F. Fasten electrical luminaires and brackets securely to structural supports. Install luminaires level and plumb.
- G. Provide stems and chains for luminaires as designated by the Owner's Representative where deemed necessary by the Owner's Representative to achieve a functional and neat installation. Contact Owner's Representative to determine pendant, stem, and chain lengths if mounting height is not indicated.
- H. Wear clean white cotton gloves when handling the luminaires reflective and diffusing surfaces. Clean surfaces including dust, finger prints, paint, etc. with a clean dry cheesecloth after interior work has been completed. Remove plastic shipping bags from luminaires only after work in the respective area is complete.

- I. Where applicable, verify that measured illuminance values comply with respective isolux (or equivalent) plot diagram values.
- J. Provide full assembly for luminaires that are shipped with any loose components, regardless of who furnishes the luminaires.
- K. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems." Install labels with panel and circuit numbers on junction and outlet boxes. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs. Identify applicable components with device address. Label each device cable within 6 inches of connection to bus power supply or termination block where applicable. Create a directory to indicate loads served by each circuit; incorporate Owner's final designations. Obtain approval before installing. Use a computer to create directory; handwritten directories are unacceptable.
- L. Install surface and recessed ceiling luminaires on grid and tile ceilings to agree with module of ceiling either displacing a tile, or unit on center of tile, or centered on grid lines.
- M. Where special mounting conditions are encountered, such as mounting to rounded columns or similar special circumstances, provide special factory fabricated mounting means (i.e., brackets designed to conform with curvature of rounded columns, or to conform with similar special surfaces).

### **3.2 AIMING AND FOCUS OF THEATRICAL LIGHTING EQUIPMENT**

- A. General
  - 1. Prior to scheduling of the vendor's field service representative for the final aiming and focusing of the theatrical lighting, confirm the following conditions:
    - a. The Dimming System has been commissioned and operational and voltage to theatrical lighting is operating at least 10% below the light sources rated voltage.
    - b. Light sources are operational. (Make available on site 10% or minimum of (4) spare light sources for each type being used for the lighting equipment installed in the event there are premature lamp failures during the aim and focus session. These spare light sources may only be utilized to replace any lamp failures during focus and may not to be taken into consideration as part of the Spare Lamp Stock required as stated in specification section 265113).
    - c. Include rental costs and make arrangements to have an appropriate Self-Propelled Elevating Work Platform, referred to as personnel lift, and qualified operator on site and available to the vendor's field service representative prior to scheduling.
    - d. Confirm that Owner's millwork, displays, artwork, statuary's, etc. have been installed, mounted or placed in their respective final locations.
    - e. Make arrangements for the Owner's Representative to be available on site at the time of the aim and focus session to assist in providing direction for specific aiming desired. Day and time of day shall be at the discretion of the Owner.
  - 2. Additional Services: Where aim and focus sessions are requested by any party, in addition to the final aiming as outlined above, negotiate costs (if any) for these services and have contract acceptance prior to scheduling.

**3.3 FIELD QUALITY CONTROL**

- A. Systems Integration, Equipment Integration Meeting Visit: Coordinate meeting between Owner's Representative, Lighting Control System Manufacturer, Design Professional(s), installers, and other related equipment manufacturers' representatives to discuss equipment and integration procedures and review system operation and sequence of operation. The intent is to make sure each party understands how the system should operate after installation and how it should be installed, and to ensure full compatibility between all associated elements of the system. Wire several test components, then verify correct installation with the manufacturer prior to wiring the remainder of the installation.

**3.4 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Factory-authorized service representative shall make a minimum of 2 site visits to ensure proper system installation and operation.
  - 2. Complete installation and startup checks according to manufacturer's written instructions.
  - 3. Activate light fixtures and verify that all lamps are operating at 100 percent.
  - 4. Burn-in all light sources that require specific aging period to operate properly, prior to occupancy by Owner.
  - 5. Confirm correct communications wiring, initiate communications between devices and controls, and program the lighting control system according to approved configuration schedules, scenes, input override assignments, etc.
- B. Contact manufacturer at least 10 days before training or turnover of project. Have manufacturer remotely connect to the control system, run diagnostics and confirm system programming. Be available on site at the time of this remote connection to perform any corrections required by manufacturer.
- C. Provide 24/7 telephone factory support that is available at no additional cost to the installer and Owner during and after the warranty period. Pre-program the system from the factory per plans and approved submittals, to the extent data is available.
- D. Provide system programming including wiring documentation, switch operation, remote overrides. Program and document scenes and schedules.
- E. Engage a factory authorized technician to confirm proper installation and operation of lighting control system components. Provide a written statement verifying that the system meets system requirements including the following.
  - 1. Confirm entire system operation and communication to each device.
  - 2. Confirm operation of individual relays, switches, sensors, etc.
  - 3. Confirm system programming, settings, etc.
  - 4. Provide training to cover installation, maintenance, troubleshooting, programming, and repair and operation of the lighting control system. Confirm that sensors are located, installed, and adjusted as intended by the factory and the contract documents.
  - 5. Sensors are operating within the manufacturers specifications.
  - 6. Sensors and controls interact as a complete and operational system to meet the design intent.



7. Engage factory-certified field service engineer to perform a site visit to ensure proper system installation and operation under following parameters:
  - a. Qualifications for factory-certified field service engineer:
    - 1) Minimum experience of 2 years training in the electrical/electronic field.
    - 2) Certified by the equipment manufacturer on the system installed.
  - b. Make a visit upon completion of installation of modular dimming control system:
    - 1) Verify connection of power feeds and load circuits.
    - 2) Verify connection and location of controls.
    - 3) Perform final programming of system data.
    - 4) Verify proper connection of digital control links.
    - 5) Verify proper operation of manufacturers interfacing equipment.
    - 6) Obtain sign-off on system functions.
    - 7) Train users on system operation.

### **3.5 ADJUSTING**

- A. Make adjustments and perform settings/programming to lighting control systems so that all luminaires are fully operational compliant with design requirements and to the satisfaction of the Owner and Design Professionals. Provide remote connection software at no added cost to system Owner.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark. Adjust aimable luminaires in the presence of Owner.
- C. Provide additional remote programming at no additional cost as required by the installer and Owner for the operational life of the system.

### **3.6 DEMONSTRATION**

- A. Engage factory authorized technician to train Owner's personnel in the operation, adjustment, programming and maintenance of the theatrical lighting and control system including ancillary components, programming, operation, functions, etc. Provide minimum of eight hours over two days of factory on-site training.

### **3.7 SYSTEM COMMISSIONING AND TESTING**

- A. General: Notify vendor in writing, at least 21 days prior to requested startup date, that the system is ready for startup. Bear costs of additional or repeat visits due to delay, lateness, or negligence on the part of the installer. Prior to operational checkout, confirm the following conditions.
  1. All controls are installed and terminated per the vendor's integration drawings.
  2. Availability of Owner's staff for instruction.
  3. Space is clear of workmen and may be blacked out for extended periods.
  4. Building and equipment feeders are energized.
  5. HVAC systems are operational in control booths/areas and Dimmer Equipment Spaces
  6. Luminaries are installed and connected to the control system to confirm that individual controlled circuits are in operational order.

7. Dimmer rack and all equipment is cleaned and ready for operational check-out.
- B. Testing: The vendor's Field Service Representative shall complete the following.
1. Inspect the installation for conformance to vendor's instructions.
  2. Confirm all wiring runs and termination and make notes as required.
  3. Make notes and diagrams as needed for completion of As-Built Documents as specified elsewhere in this section. Make note of any deviations from vendor's directions.
  4. Measure incoming voltages at the dimmer rack and record.
  5. Configure Dimmer rack, console, stations and other components for proper operation.
  6. Test each wired space of Dimmer Rack for proper operation.
  7. Test all control stations, consoles and auxiliary controls for proper operation.
  8. Replace any equipment not operating as specified.
  9. Test all load circuits for proper dimming operation, from 0 to 100% with a minimum 500-watt load.
- C. Training: A knowledgeable representative of the vendor shall instruct the Owner's Staff or Representatives in the operation and maintenance of the system. This instruction session shall be scheduled to last a minimum of four hours. While it may be possible to schedule this instruction session to coincide with the system checkout, such coincidence shall not be assumed.

### **3.8 MAINTENANCE**

- A. Manufacturer shall be capable of providing on-site service support within 24 hours anywhere in continental United States (and within 72 hours worldwide except where special visas are required). Offer renewable service contract on yearly basis, to include parts, factory labor, and annual training visits. Make service contracts available up to ten years after date of system startup.

**END OF SECTION 26 5561**

**SECTION 27 0001****COMMON WORK RESULTS FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, Division 27 Specification Sections, and Division 28 Sections (if applicable) apply to all sections.
- B. Related Drawings
  - 1. All Technology (T-Series) Drawings

**1.2 GENERAL DIRECTION**

- A. Submittal of a bid indicates that the contractor has examined the drawings, specifications, and had an opportunity to visit the site to be able to provide a comprehensive complete bid.
- B. The intent of these specifications and the accompanying drawings is to provide complete and workable systems as shown, specified and required by applicable codes. Interpret these specifications in conjunction with the drawings and provide all work described. If work is shown on drawings and not mentioned in the specifications, or vice versa, it is to be included in the work the same as though clearly set forth by both. Should there be a conflict between the specifications and drawings, provide the greater quantity or better quality. Immediately notify owner's representative and design professional of such conflicts.
- C. The drawings that accompany these specifications are diagrammatic and although size and location of equipment is drawn to scale, wherever possible make use of submittal data and verify all dimensions on site. They do not show every conduit, offset or pull / junction box which may be required to install work in the space provided and avoid conflicts. Follow the drawings as closely as is practical and install additional pull / junction boxes and offsets where required by site conditions and codes at no additional cost. Install all new work in such manner as to conform to the structure, avoid obstructions, provide required service clearances and preserve headroom. Do not scale from drawings, measurements shall be taken in the field.
- D. Coordinate all new work with all other contractors and installers in addition to existing building obstructions and install accordingly. Refer to coordination drawings of other trades. Comply with requirements of architectural drawings including but not limited to mounting height and locations.
- E. Fully research peculiarities and limitations of space available for installation of work with materials being provided. Work around material lead times to not extend project schedule.
- F. Complete work, or part(s) thereof, at times as may be designated by the Owner's Representative, so that it can be used for temporary or permanent use. Do not construe such use of the system as an acceptance of it by Owner.

- G. During mobilization or construction, if an abnormal condition is uncovered either with existing conditions, equipment loads, submittal data, etc. bring these to the attention of the Design Professional for review.
- H. Owner's Representative or Design Professional may relocate fixtures, devices, equipment, etc. prior to installation within a 20-foot limit at no additional charge.
- I. Phasing - Where the scope of work dictates that the project shall be constructed in phases, all costs shall be incurred by this contractor for any temporary work required so that previous phases can be operational while construction is being done to adjacent spaces.

### **1.3 GENERAL STANDARDS**

- A. Provide work in compliance with applicable provisions of the following standards. Provide listing and labeling for all electrical materials, marked for respective intended uses, from UL or other Nationally Recognized Testing Laboratory (NRTL) that is acceptable to applicable Authorities Having Jurisdiction (AHJs).
- B. Provide materials, installation methods, workmanship, testing, etc., in strict accordance with the latest edition of applicable standards and adopted codes, including (but not limited to) the following.
  - 1. International Building Code
  - 2. State Building Code and applicable amendments
  - 3. State Energy Code
  - 4. Utility company requirements and standards as applicable
  - 5. All provisions and requirements of NFPA (National Fire Protection Association)
  - 6. National Electrical Code (NEC), NFPA 70
  - 7. Life Safety Code, NFPA 101
  - 8. Local governmental and other prevailing codes and ordinances
  - 9. ADA/ADAAG requirements (American with Disabilities Act) including all applicable Standards for Accessible Design.
  - 10. UL (Underwriters Laboratories Inc.)
  - 11. ETL (Intertek Testing Services NA, Inc.)
  - 12. CSA (CSA Group Testing and Certification Inc.)
  - 13. FM (Factory Mutual Insurance Company)
  - 14. ASME (American Society of Mechanical Engineers)
  - 15. NEMA (National Electrical Manufacturers Association).
  - 16. NECA (National Electrical Contractors Association)
  - 17. IP (International Protection Rating / Ingress Protection Rating)

### **1.4 PERMITS AND REGULATIONS**

- A. Obtain and pay for permits, fees, certificates of inspection and approval, etc. required for this branch of the work. Furnish Owner with certificates of final inspection and approval prior to final acceptance of this branch of the work.
- B. Laws and regulations which bear upon or affect the various branches of this work shall be complied with by this contractor and are hereby made a part of this contract.

**1.5 DEFINITIONS**

- A. Furnish - Procure, supply and deliver to project site, ready for installation, install and warrant (unless indicated otherwise on documents). Include warranty expenses.
- B. Install - Assemble, wire and connect loose-shipped components on site. Place in position for service or use, including material, labor, accessories, services, and testing. Wire, connect, and render fully operational for intended use.
- C. Provide - Furnish and Install. Similar Terms: "include", "shall", "equip with", "consisting of"
- D. Equal or Equivalent - Determination of equivalency to be made by design professional for all products not listed as basis-of-design.
- E. Substantial Completion - Where frontend documentation does not define, products and systems must be fully installed as designed, tested, adjusted, labeled, and functionally demonstrated to owner.
- F. High Voltage: For the sake of this Division, greater than 70.7vac RMS; greater than 100vac P-P; greater than 49vdc.
- G. Low Voltage: For the sake of this Division, less than or equal to 70.7vac RMS; less than 100vac P-P; less than or equal to 49vdc.
- H. Structured Cabling: A standardized repetitive passive physical infrastructure of cables, conductors, terminations, hardware and supporting products that together are used to enable the conveyance of signals, information, and data between different locations. Such systems are commonly constructed in accordance with standards published by various standards organizations, including but not limited to the TIA, EIA and BICSI. In some cases, specialized derivatives of these standards are constructed to meet specialized system needs. Common usages of structured cabling systems include such things as computer or data networks (including wireless infrastructure), telephone systems, building automation systems, electronic safety and security systems, and building intercommunications systems. The structured cabling system does not include any active electronic equipment.
- I. Audio-Visual / Audio and Video Systems Work: That portion of the Project that involves the supply, installation, programming, or testing of products whose fundamental purpose is the reproduction, pickup, storage, transporting, processing, control of audio and/or video signals. Scope of this definition includes all incidentals that are regularly and fundamentally required to provide complete and working systems from the small and simple to the large and complex.

**1.6 REQUESTS FOR INFORMATION**

- A. Submit all questions, requests for information (RFIs) and similar queries through the formally-established RFI process for the project that has been accepted by the Owner's Representative, Design Professionals, Prime Contractor and subcontractors. Submit as a PDF file. Do not submit as text in an email.

**1.7 AVAILABILITY OF ELECTRONIC DRAWINGS**

- A. If expressly permitted by the Owner and the terms of the Contract, editable electronic drawings may be made available for the creation of shop and as-built drawings upon request. Drawings will be made available at the discretion of the Engineer.
- B. "Request Drawings" form can be accessed, filled out and submitted at <http://www.klhengrs.com> (right hand side of page - Contractor Resources). Direct access to this form can be found here: <http://files.klhengrs.com/requestdrawings.html>
- C. Acronyms and Abbreviations:
1. ADA: Americans with Disabilities Act.
  2. ANSI: American National Standards Institute.
  3. AWG: American Wire Gauge.
  4. BICSI: Building Industry Consulting Services International.
  5. BOM: Bill of Materials.
  6. Bps: Bits per second.
  7. LEC: Local Exchange Carrier.
  8. dB: Decibel.
  9. Device ID: A system specific label assigned to a product to uniquely identify it within a given a system.
  10. DSL: Digital Subscriber Line.
  11. EF: Entrance Facility.
  12. EIA: Electronics Industries Association.
  13. EMI: Electromagnetic Interference.
  14. ER: Equipment Room (a type of Communications Room).
  15. Gb/s (Gbps): Gigabits per second.
  16. GHz: Gigahertz.
  17. IDF: Intermediate Distribution Frame (Replaced by TR).
  18. IEEE: Institute of Electrical and Electronics Engineers.
  19. ISO: International Organization for Standardization.
  20. ISP: Internet Service Provider.
  21. LAN: Local Area Network.
  22. MAC: Media Access Control.
  23. Mb/s (Mbps): Megabits per second.
  24. MDF: Main Distribution Frame (Replaced by ER).
  25. MHz: Megahertz.
  26. MPLS: Multi Protocol Label Switching.
  27. OFCI: Owner Furnished Contractor Installed.
  28. OFE: Owner Furnished Equipment.
  29. OFOI: Owner Furnished Owner Installed.
  30. PoE: Power over Ethernet.
  31. PSTN: Public Switched Telephone Network.
  32. QoS: Quality of Service.
  33. RAID: Random Array of Inexpensive Disks.
  34. RAM: Random Access Memory.
  35. RFC: Request for Comment.
  36. RFI: Request for Information/ Radio Frequency Interference.
  37. RFP: Request for Proposal.
  38. RFQ: Request for Quotation.
  39. SNMP: Simple Network Management Protocol.
  40. SSD: Solid State Drive.
  41. TB: Terabyte.

- 42. TCP: Transmission Control Protocol.
- 43. TCP/IP: Transmission Control Protocol/Internet Protocol.
- 44. TIA: Telecommunications Industries Association.
- 45. TR: Telecommunications Room (a type of Communications Room)
- 46. VoIP: Voice over Internet Protocol.

- D. Provide the services of locally licensed and authorized electrician(s) to perform that portion of the Work of this Division that is required by the applicable codes and/or the AHJ to be performed by licensed electrician(s).

## **1.8 ADMINISTRATION**

- A. Progress Meetings:
  - 1. Progress meetings may be established to review progress of the Work, discuss anticipated progress during the following weeks, and review critical operations and existing and potential problems.
  - 2. Contractor(s) shall attend and shall be represented at every progress meeting by a person authorized with signature authority to make decisions regarding possible modification of the Contract Documents.

## **1.9 WARRANTY / GUARANTEE**

- A. Provide a warranty/guarantee in written form as part of O&M manual stating that all work, materials, equipment and parts are warranted to be free of defect for a minimum period of one year from the date of Substantial Completion. Warranty period and requirements may be expanded in drawings or subsequent specification sections. Repair or replace (owner's option) any defects or failures at no cost to the owner within the warranty period. Issues arising within warranty period must be attended to in a timely manner and in no case exceed four (2) working days. State this in writing as part of O&M manual. Replace defective items to the satisfaction of the Owner's Representative and the Design Professional.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Materials, apparatus and equipment shall bear the Underwriter's Laboratory, Inc. label (or other nationally recognized testing laboratory label) where regularly supplied, and as additionally required by Code or the Contract Documents.
- B. Products furnished shall be new, full weight and of the best quality. Similar supplied materials shall be of the same type and from the same manufacturer.
- C. If a specified product is discontinued by the manufacturer and is no longer available for purchase, replacement product of equal or greater value, performance and function as the discontinued Basis of Design product shall be furnished. The replacement product shall be from the same manufacturer as the Basis of Design product unless written permission has been granted by the Designer. The Contractor is solely responsible for researching and submitting proposed replacement product. The final decision as to whether a Contractor proposed replacement is acceptable lies solely with the Designer.



- D. Substitute products shall only be considered if the Contractor has strictly adhered to the guidelines set forth under “Substitutions” as defined in this Section.

## **2.2 BASIS OF DESIGN**

- A. Some of the Contract Documents are prepared on the basis of specific products that are designated as the “Basis of Design.”
- B. The Basis of Design products for the Work of this Division are designated explicitly within the specifications, and in the case of some products, designated by brand and model on the Drawings.
  - 1. Where a product brand and model is expressly identified on the Drawings, this product represents the Basis of Design for that instance of the product in the associated system.
- C. The combination of Basis of Design products and the interconnection thereof collectively represent a work that includes the feature set and performance intended by the Designer and the Owner. The specifications may identify additional manufacturers whose equipment may be used in the system, provided the use of such products achieves the same capabilities and performance as that of the specified combination of the Basis of Design products.
  - 1. Due to the varied and integrated nature of modern communications products, there is no guarantee that any single product manufactured by any one of the listed additional manufacturers will be an exact equivalent to a single Basis of Design product in terms of functionality, capability or performance. Therefore, where the use of substitute product is considered, the product shall be verified by the substituting party to include the capabilities, features and performance as that of the Basis of Design product.
  - 2. Work of the Contract shall include covering the cost of additional products and labor necessary to achieve the same end results as would be achieved by using the specified combination of Basis of Design products, including additional costs for coordination, modifications to the building, pathway modifications, casework and furniture modifications, power modifications, licensing, or anything else that may cause additional expense to the Owner.
  - 3. In addition, costs incurred by the Owner’s design team to accommodate such changes shall be the responsibility of the party making the substitution.

## **2.3 SUBSTITUTIONS**

- A. A substitution is the use of any product other than that identified as the “Basis of Design,” the “Standard of Quality,” or an “Additional Approved Product.”
- B. Substitutions require pre-bid approval. Only substitutions authorized via addendum shall be considered.
- C. Substitutions are considered on a product-by-product and model specific basis.
- D. Substitution Submittal Requirements:
  - 1. Substitution requests must be received by the Designer sufficiently in advance of the scheduled bid date to allow time for review and issuance of an Addendum. If the timing of the request does not permit an Addendum, substitution shall not be considered or acceptable.

2. Substitution requests shall consist of the following for each proposed substitution:
  - a. Substitution Request Letter
  - b. Product Datasheets/Brochures
- E. Costs that result from the use of substitute products and/or Additional Approved Manufacturer(s), including costs for additional equipment, coordination, accessories, modules, interface products, cables, software, and programming, as well as costs for any additional labor, materials, and products incurred by other trades or members of the project Design Team or Owner, are the sole responsibility of the Contractor making the substitution. This includes costs that may not be incurred or known until after Contract award or Work execution. Such costs shall be deducted from final sum payable to the Contractor.
- F. Post Contract award substitutions may be considered, but only if the proposed substitution includes substantial additional benefit to the Owner. Post award substitutions are considered solely at the discretion and convenience of the Designer. For a post Contract award substitution to be considered, one or more of the following shall apply:
  1. The Designer initiates the request for substitution.
  2. A basis of design product has become discontinued and is no longer available, and as a result, the use of a substitute product has become a necessity to meet the Owner's objectives for the Project. See "Discontinued Products."
  3. The request for substitution is accompanied by a proposal that identifies the benefits to the Owner, including a fair-market Contract price reduction.

## **2.4 DISCONTINUED PRODUCTS**

- A. The availability of products shall be verified by the Contractor prior to submitting pricing for Work of the Contract.
- B. In the event that a specified product is discontinued at any time and becomes unavailable for use on the Project, provide a replacement product deemed acceptable to the Designer. Replacement product shall be of equal or greater value, performance and functionality.
  1. Replacement product shall be from the basis of design manufacturer, from one of the additional product manufacturers identified for the product within the Section, or from another manufacturer deemed acceptable to the Designer.
- C. The cost for the supply and installation of suitable replacement product is the sole responsibility of the Contractor.
- D. Replacement products are considered substitutions and require Designer review and authorization. See "Substitutions."

## **PART 3 - EXECUTION**

### **3.1 WORK AND WORKMANSHIP**

- A. Provide labor, materials, equipment and services necessary for complete installation of systems required to comply with the requirements of authorities having jurisdiction (AHJ), as indicated within the Contract Documents.

- B. Work shall be functional and complete in every detail, including items required to complete the system, regardless of whether each necessary item is fully enumerated in the Specifications or shown on the Drawings.
- C. Contractor and Subcontractors shall be knowledgeable of the details of Work to be performed by other trades and take necessary steps to integrate and coordinate Work of this Division with that of other Divisions and other trades.
- D. Wherever tables or schedules show quantities, they shall not be interpreted to represent the total contract quantity requirement, but instead a portion of the Contract requirement. The Contractor shall be responsible for the higher quantity communicated by the Drawings, within the Specifications and on the schedules/tables. Seek clarification from the Designer should a discrepancy be found.
- E. The Designer and Owner's Representative may, at their sole discretion, condemn or reject any Work, materials or equipment not in accordance with the Contract Documents or the manufacturer's specifications or drawings reviewed by the Designer or Owner.
- F. Work or equipment that is rejected shall be removed and replaced to the satisfaction of the Owner and Designer at the Contractor's expense. Work or equipment that is rejected shall be so stated in writing by the Owner or Designer.
- G. Work shall fully comply with the Contract Documents and manufacturer's recommended installation guidelines.
- H. Work shall be performed with the best practices of the trade for performance, functionality, safety, endurance and aesthetics.
- I. Coordinate ordering and installation of equipment with long lead times or having a major impact on work by other trades so as not to delay the job or impact the schedule.
- J. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible. Consult the Designer for direction.
- K. Supply scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from premises when no longer required.
- L. Work shall be installed level and plumb, parallel and perpendicular to prevailing building lines, except as expressly detailed otherwise or required for proper form, function or Designer-intended operation.
- M. Specialty tools shall be used for assembly, installation, termination, and removal of products as recommended by the product manufacturer.

**3.2 TESTING**

- A. General:
  - 1. Upon complete physical installation of products, align, balance, and adjust equipment to make it usable to the Owner for the intended purpose, and ensure compliance with the Contract Documents.
  - 2. Test each system and each component thereof, and correct deficiencies prior to scheduling acceptance testing.
  - 3. Replace malfunctioning or damaged products with new product, following immediately with retesting until satisfactory performance and specification compliant conditions are achieved.
- B. Operational Testing:
  - 1. Perform operational testing of supplied products individually and collectively to verify conformance with the Contract Documents, to ensure compliance with the product manufacturer's published specifications, and as additionally necessary for the system to meet the intended purpose.
- C. Performance Testing:
  - 1. Perform measurements and testing necessary to demonstrate performance compliance.

**3.3 TRAINING**

- A. Training shall be supplied for each Section of this Division and for each unique system provided.
- B. The Owner shall have the right to use the total allocated training for a period of 1 year following final completion of onsite work, solely at its discretion.
- C. Training shall be supplied as expressly identified within individual Sections. Where training requirements are not otherwise expressly identified, the Contractor shall furnish a minimum of two (2) hours per unique system, per Section. The Contractor shall presume that at least two (2) discrete trips to the project site shall be required per unique system to conduct training.
- D. Training dates and times shall be coordinated with the Owner's designated training representative(s).
- E. Training shall cover the following:
  - 1. Normal system use and operation.
  - 2. Procedures and schedules involved in troubleshooting and performing routine preventative maintenance.
  - 3. Other facets as identified in individual Sections.
- F. Agenda and relevant training handouts shall be prepared and distributed to attendees at each training session.
- G. A sign-in sheet shall be created and used for each training session. The sheet shall identify the following, at a minimum:
  - 1. Specification Section reference and system(s) being trained.

2. Date and starting time of the session.
3. Signatures of attendees.
4. Ending time of the session, along with a separate owner signature certifying the ending time.
5. Training outline/agenda.

H. Recording of Sessions:

1. Recordings shall be supplied on DVD video format media playable in standard consumer grade reproduction appliance. Recordings do not need to be professionally edited but shall feature intelligible audio and a clear image of the subject trainer and any supplemental visual content material to the training.
2. Recordings shall be turned over and signed for by an Owner's training representative at the end of each session. A copy of a signed delivery receipt shall be included as part of the closeout documentation.
3. Contractor shall require each attendee to sign-in at the start of each training session. The sign-in form shall summarize the training conducted, specification section reference and system being trained on, as well as the starting time and duration of training. Following training, a representative of the Owner shall sign the form, acknowledging the same. Contractor shall retain the original copy of these forms and turn over a photo copy of the form to the Owner's representative as evidence of training. Training conducted without this official record of training shall not be considered as part of the Contractor's training obligation.

I. For a training session to count towards the training obligation, each of the following shall be met:

1. Training occurs after Training Submittal review.
2. Training session outlines / agenda are distributed at the session.
3. Quality Assurance requirements for the instructor have been met.
4. Training occurs after the system / section is complete and working as intended by the Contract Documents, usually following Acceptance Testing. Training in advance of this requires Designer approval.
5. Sign-in sheets are used, completed and retained for the session.
6. A master log of training conducted for the project is maintained.

**END OF SECTION 27 0001**

**SECTION 27 0002****QUALITY ASSURANCE FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Quality Assurance:
  - 1. Quality Assurance: General Qualifications.
  - 2. Quality Assurance: For Structured Cabling Systems Work.
  - 3. Quality Assurance: For Audio and Video Systems Work.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Quality Assurance requirements for Work of this Division.
- B. Related Requirements
  - 1. Related Sections
    - a. All Division 27 Sections.

**1.3 QUALITY ASSURANCE**

- A. General Qualifications:
  - 1. Business history of the last five (5) contiguous years performing work of similar type, value and scope as that required of the Contract Documents.
  - 2. Capable of demonstrating through valid references and other means that it has successfully completed no less than six (6) projects of similar type, monetary size, and scope of work within the last twenty-four (24) calendar months.
  - 3. A "Factory-authorized" reseller (e.g., distributor, dealer, integration partner, value-added reseller, channel partner) for the products furnished for each Section.
  - 4. House substantial business operations within a 300-mile radius of the project site.
  - 5. Employ full-time service staff based within a 50-mile radius of the project site.
  - 6. Financial Disclosure of the Contractor: Prior to contract award, upon request.
- B. Superintendent/Project Manager Qualifications:
  - 1. Furnish the services of an experienced superintendent/project manager who shall be constantly in charge of the Work, together with a qualified foreman and technical specialists to properly install, connect, adjust, start, operate and test the Work involved.
  - 2. Qualifications are subject to the review and acceptance by the Designer and Owner. Unless the Designer and Owner grant prior permission, the same superintendent/project manager shall be utilized throughout the duration of the Project and shall remain responsible for the complete scope of the Work.
- C. Subcontractor Qualifications:
  - 1. If the Contractor, as a singular entity, does not meet 100-percent of the quality assurance requirements for each specification section, the Contractor shall enlist the services of

- qualified subcontractors to perform the Work of those specific section(s). This includes, but is not limited to, the supply of the products for the Section and the supply of the project engineering services, preparation of shop drawings and section submittals, technical installation labor, training, warranty, post-installation support and service.
2. The Contractor shall ensure that each subcontractor supplies the services of a project manager to represent its interests at the same project meetings in which the Contractor participates.
  3. The Designer and Owner reserve the right to disqualify the use of any subcontractor that does not meet the quality assurance requirements set forth in these specifications. Should a subcontractor be disqualified, the Contractor shall supply the services of a different subcontractor that complies with the published quality assurance requirements. The Contractor is solely responsible for costs incurred as a result. It is therefore incumbent upon the Contractor to pre-qualify subcontractor choice(s) prior to submitting pricing for work.
  4. To achieve quality assurance compliance, an equipment vendor that is not performing the technical installation labor associated with work of a Section shall not be considered a subcontractor.
- D. Training Qualifications:
1. Personnel conducting training shall be knowledgeable of the product, system and technology on which they train. Personnel shall be factory trained, factory certified and/or otherwise recognized by the Designer as possessing sufficient experience and knowledge in the subject area.
- E. Additional Qualifications for Structured Cabling Systems Work:
1. Provide BICSI Certified Registered Communication Distribution Designer (RCDD) and BICSI Certified Technicians who shall be responsible for the Project.
    - a. The RCDD shall be a current BICSI member in good standing. The RCDD shall have sufficient experience in this project type and provide technical support to the field during installation, warranty period, and extended warranty periods and maintenance contracts.
    - b. The lead technician responsible for the Project shall be a BICSI member in good standing and shall be a BICSI Certified Technician.
    - c. Installers shall meet minimum certification requirements to meet the cabling and connectivity manufacturers' certifications and warranty requirements, as identified in individual specification sections.
  2. The RCDD and Lead Technician(s) on the Project shall have a thorough understanding of the following, and Work performed shall be compliant with the following:
    - a. TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
    - b. TIA/EIA-569-C, or most current version, Telecommunications Pathways and Spaces.
    - c. TIA/EIA-590-A, or most current version, Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant.
    - d. TIA/EIA-606-B, or most current version, Administrative Standard for Commercial Telecommunications Infrastructure.
    - e. TIA/EIA-607-B, or most current version, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.



- f. The most current published edition of the "Telecommunications Distribution Methods Manual" published by the Building Industry Consulting Services International (BICSI).
    - g. TIA/EIA-758-B, or most current version, Outside Plant Cabling Systems.
    - h. The most current published edition of the "Outside Plant Design Reference Manual" published by the Building Industry Consulting Services International (BICSI).
  3. Staff, including RCDD(s), BICSI Technician(s), and installers, shall be manufacturer-certified to meet the requirements to obtain the warranty specified for the systems.
  4. Installation practices shall be compliant with referenced and applicable standards, regulations, and codes.
  5. Submittals, including shop drawings, shall be prepared by, or under the direct supervision of the RCDD.
    - a. Each submittal, including shop drawings, shall be reviewed, signed and stamped with the RCDD stamp and signature of the responsible RCDD.
  6. Each as-built drawing shall be prepared by, or under the direct supervision of the RCDD.
- F. Additional Qualifications for Audio and Video Systems Work:
  1. AV Project Engineer:
    - a. AVIXA CTS-D® Certified, and;
    - b. Manufacturer trained on key products being installed.
  2. AV Technician Qualifications:
    - a. AVIXA CTS-I® or CTS-D® Certified, and;
    - b. Manufacturer trained on key products being installed.
  3. AV Installer Qualifications:
    - a. AVIXA International CTS-I® Certified.
  4. Shop drawings shall be prepared by, or under the direct supervision of a qualified AV Project Engineer. Each shop drawing shall be reviewed, signed and stamped with the CST-D® stamp of the responsible AV Project Engineer.
  5. Each as-built drawing shall be reviewed, signed and stamped with the CST-I® stamp of the AV Technician responsible.
  6. Installation performed by other than a qualified AV Technician shall be performed by qualified AV Installers. These Installers shall perform their work under the direct supervision of a qualified AV Technician. The ratio of AV Installers to AV Technicians shall not exceed 3 to 1.
  7. System adjustments shall be made by qualified AV Technicians, AV Project Engineers, and manufacturer employees.
  8. Cabling for Audio-Visual systems shall be installed by AV Technicians, AV Installers, or BICSI ITS certified technicians.

## **PART 2 - PRODUCTS (NOT USED)**

## **PART 3 - EXECUTION**

### **3.1 QUALITY ASSURANCE SUBMITTALS**

- A. Provide documentation that demonstrates the qualification for each requirement articulated in this Section and in compliance with Section 270503 Submittals.

**END OF SECTION 27 0002**

**SECTION 27 0100****OPERATION AND MAINTENANCE OF COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTAL REQUIREMENTS**

- A. Closeout
  - 1. Operation and Maintenance Manual: For equipment and systems to include in operation and maintenance manuals.
- B. Shop Drawings
  - 1. As-Built Drawings: For recording installed conditions that deviate from design documents.

**1.2 OPERATION AND MAINTENANCE MANUAL**

- A. The contents of operating and maintenance manual shall include the following:
  - 1. Project Information Cover: Title of Project; Name and address of Owner, Design Professionals, Contractor of Record and Subcontractor; System name and specification references.
  - 2. Index: Contents of the manual.
  - 3. Warranty Statements: Furnish a warranty statement for each system, reiterating the terms of warranty identified within the Contract Documents, and identifying how the Owner is to obtain warranty service. Clearly identify which products are covered by Manufacturer warranties beyond the Contractor required minimum warranty period. The term of manufacturer warranty shall also be identified (e.g., 1-year parts and labor). Identify the date that the warranty for the system starts. This date shall be the date listed on the Certificate of Substantial Completion (if one was issued to the contractor specifically for the system) or the date listed on the Notice of Final Completion. Supply standard out-of-warranty service rates and service contact information.
  - 4. Bill of Materials: List of products supplied, and serial numbers of each product.
  - 5. Product Datasheets and Shop Drawings: Manufacturer datasheets and shop drawings for each product and system supplied.
  - 6. Manufacturer Owner / User Manuals: Manufacturer's Owner's or User's manual for each product, and Manufacturer's Installation instructions and other documentation supplied with the product.
  - 7. Extra Material Schedule:
    - a. Complete spare parts schedule for components of equipment furnished, which are not factory generic information, but accurate for the equipment provided.
    - b. Itemized list of each piece of communications, architectural and Owner equipment having communications connections with termination locations; also, list related expendable equipment required for each item as applicable.
  - 8. Maintenance Procedures: Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; testing, aligning and adjusting instructions.
  - 9. Function and Operating Descriptions: Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

10. Operating Procedures: Manufacturer's printed operating procedures including start-up, break-in, normal operating instructions, regulation, control, stopping, shutdown, and emergency instructions.
11. Include Product Certificates, Source quality-control test reports and Field Quality-Control Reports
12. Test Reports and Checklists: Test reports, checklists, and other forms generated and completed for the Project.
13. Training Information: Copy of training outlines/agendas, training session handouts, training sign-in sheets, and signed delivery receipt for each training session recording; Separate USB drive, labeled, for audio/video-recorded instructions to Owner, for operations and maintenance for each system.
14. As-Built Drawings.
15. Software: Application and operating software documentation; Software licenses; Software service agreements; Manufacturer's operating specifications; design user's guide for software and hardware; Editable configuration files for system equipment; Software source code used in supplied products; Compiled versions of configuration files and source code; IP addresses of products configured to have static IP addresses; MAC addresses of products featuring network communication ports (wired and/or wireless); Network device names for products configured for DHCP; Software required for reviewing and editing supplied files.

### **1.3 AS-BUILT DRAWINGS**

- A. Obtain two complete sets of communications prints and use them to provide progress record drawings which are separate, clean, prints reserved for the purpose of showing a complete picture of the work as actually installed (including routing of conduit and cables). These drawings also serve as work progress report sheets. Make notations, neat and legible thereon daily as work proceeds. Make these drawings available for inspection at all times and keep them at the job at a location designated by the Owner's Representative.
- B. Maintain the clean, undamaged set of prints of drawings as well as a set of submittal drawings and coordination drawings. Mark the sets to show the actual installation where the installation varies from the Documents as originally shown. Include locations of underground and concealed items if placed other than shown on the Documents. Where shop drawings are used, record a cross-reference at the corresponding location on the Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
- C. Show changes in: size, type, capacity, etc., of material, device or piece of equipment, location of device or piece of equipment; location of outlet or source of building service systems; routing of piping, conduit, or other building services. Record location of concealed equipment, by indication of measured dimensions to each line from readily identifiable and accessible walls, column lines or corners of building. Indicate approved substitutions, modifications, and actual equipment and materials installed.
- D. Affix near the title block on each drawing the Contractor's Company Name(s), signature of Contractor's Representative(s) and current date.

**PART 2 - PRODUCTS (NOT USED)****PART 3 - EXECUTION****3.1 INSTRUCTION OF THE OWNER'S PERSONNEL**

- A. Provide instruction in the proper operation and maintenance of equipment that requires routine servicing. Include the following:
  - 1. Review of operation and maintenance manuals.
  - 2. Required tools.
  - 3. Extra Materials.
  - 4. Cleaning.
  - 5. Hazards.
  - 6. Warranties and maintenance agreements.
  
- B. Demonstrate equipment and systems operation including the following:
  - 1. Start-up.
  - 2. Shut-down.
  - 3. Emergency conditions.
  - 4. Safety procedures.
  - 5. Setpoint and schedule adjustments.
  - 6. Economy and efficiency adjustments.

**END OF SECTION 27 0100**

**SECTION 27 0501****BASIC MATERIALS & METHODS****PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes: Requirements applicable to work of this Division.
  - 1. Basic materials, methods and installation guidelines applicable to the installation of all communication systems.

**1.2 QUALITY ASSURANCE**

- A. Explosives
  - 1. Use of explosives at the project site shall not be permitted.
- B. Welding
  - 1. Welding at the project site, where necessary, shall be performed only by persons licensed to perform such work at the project site(s). Welding shall require a permit and the approval of the Owner's Representative. Request for permission to perform onsite welding shall be submitted in writing through designated project channels.

**PART 2 - PRODUCTS****2.1 CABLE BUNDLING HARDWARE**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Hellermann Tyton.
  - 2. Millepede, Inc.
  - 3. Panduit.
  - 4. Velcro.
- B. General: Provide reusable, adjustable cable straps.
  - 1. Hook and Loop Fastener:
    - a. Shall be utilized within all cabinets and racks and below the ceiling of Telecommunications and Equipment rooms.
    - b. Provide plenum rated ties in plenum environments.
    - c. Minimum cable strap width shall be 3/4-inch.
    - d. Basis of Design: Velcro One-Wrap Qwik Ties.

**PART 3 - EXECUTION****3.1 COORDINATION**

- A. High Voltage Wiring
  - 1. Review all high voltage provisions for This Contractor's work with the Division 26 electrical contractor. Coordinate specific device termination, loading and circuiting requirements with the electrical contractor.
- B. Coordinate installation of new pathways with parties and the Work that will utilize the pathways, prior to installation.
- C. Review pre-existing pathways prior to installation of the Work, and report to the Designer any discrepancies between specified pre-existing pathway conditions and actual existing pathway conditions.
- D. Participate in coordination efforts through the preparation of shop drawings and details prior to fabrication or installation of any products. Coordinate actual clearance requirements of installed products.
- E. Begin coordination immediately upon award of contract. Coordinate the Work with other parties and adjust equipment locations accordingly. Participate in the preparation of coordination drawings.
- F. Devices and equipment shall be located symmetrical with architectural elements and shall be installed at the heights and locations shown on the Drawings. If a height or location is in question, seek immediate clarification from the Designer.
- G. Evaluate the Contract Documents and existing conditions to gain an understanding of the peculiarities and limitations of the spaces where the Work is to be performed. The final Work shall be accessible for servicing. Although the locations of equipment and conduit may be shown on the Drawings in certain positions, the architectural details and conditions existing on the Project shall guide the Contractor, coordinating the Work with that of others. Provide necessary offsets to provide a neat workmanlike arrangement.
- H. The Drawings are generally diagrammatic and indicate the design intent, required sizes, points of termination and, in some cases, suggested routes of raceways. However, it is not intended that the Drawings indicate fully coordinated routing and placement or necessary offsets.
- I. Refer to each Drawing, including enlarged plans, elevations, sections, and details for additional information that may include dimensions and greater resolution and notes that serve to refine the intent and further assist and guide installation.
- J. Work in harmony with other parties performing work at the project site so as not to cause any delays in pouring concrete or erecting masonry walls. Consult each Contract Drawing, including those predominately used by other trades, before installing Work so as to ensure that performance of Work will not interfere with or be adversely affected by Work of others.

- K. Attend each regularly scheduled project meeting as well as any special meetings called to coordinate and/or resolve special issues that arise during the course of the Project.
- L. Conflicts in equipment and materials shall be corrected prior to installation. Should there be a conflict with drawings of other trades, work with the other trades to correct the conflict while coordinating the Project (prior to installation). If a conflict cannot be resolved, seek the direction of the Owner's representative. Refer to the drawings used by other trades for details, dimensions and locations of their work and route around their work so as not to conflict. Work installed that creates a conflict shall be removed and readjusted to the satisfaction of the Owner's representative at the Contractor's expense.

### **3.2 INSTALLATION**

- A. General:
  - 1. Cabling installed within open ceilings shall be ran in conduit or fully concealed from view behind the building structure.
  - 2. Work installed in finished areas shall be concealed.
  - 3. Sequence, coordinate, and integrate installations of communications materials and equipment with the work of other trades for efficient flow of the Work.
  - 4. Install systems, materials, and equipment to conform to reviewed submittal data, including coordination drawings.
  - 5. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and architectural/structural components (prevailing building lines), except as expressly detailed otherwise or required for proper form, function or Designer intended operation. Except where otherwise specified, detailed or directed by the Designer, install visible products level to within 1/8-inches per 100-feet.
  - 6. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.
  - 7. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
  - 8. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
  - 9. Verify dimensions by field measurements. Take measurements and be responsible for exact size and locations of all openings required for the installation of work. Figured dimensions are reasonably accurate and should govern in setting out work. Where detailed method of installation is not indicated or where variations exist between described work and approved practice, direction of the owner's representative on job shall be followed.
  - 10. If during construction it becomes apparent that certain minor changes in layout would result in a neater appearance or better arrangement, such alterations shall be made as part of the Contract. Designer's review shall be obtained before making such changes.
  - 11. Workmanship throughout shall conform to the standards of best practice. Marks, dents or finish scratches shall not be permitted on any exposed materials, fixtures or fittings. Interiors of panels and equipment boxes shall be left clean.
- B. Cabling
  - 1. Use caution not to exceed the manufacturer allowed bending radius for cables and not to compromise the integrity of the cables during installation by pulling cable management devices too tightly, damaging cables. Raceway/cabling bending radii shall be minimum as directed by cable manufacturer. Use pulling compound or lubricant where necessary to ensure cable does not experience tension beyond manufacturer limits during installation.



Compounds used shall be compatible with the cable and pathway products and shall not cause deterioration of either.

2. Where indicated, provide color-coded jackets to identify runs of different systems.
  - a. See related specifications and drawings for applicable color coding.
3. Neatly route cables parallel and perpendicular to building architectural lines.
  - a. Cables and cable assemblies shall be run as straight as possible and symmetrical (perpendicular to or parallel with) with architectural items and at a consistent elevation. Work installed diagonal to building members shall not be permitted.
4. Neatly comb out multiple cable bundled runs to remove tangling and crossing of cables within the bundles. Neatly dress all cable work and provide vertical and horizontal cable management (or other approved method) for properly dressing all work at racks, control panels, backboards etc. See detail(s) if applicable.
  - a. To avoid Alien Crosstalk, do not cinch UTP cables into tight bundles.
5. Cable shall be installed within approved pathways. Cables not installed within raceway, cable tray or ladder rack shall be supported by discrete cable supports. Support cables at box and faceplate.
6. All penetrations to walls and floors designed to shall include metal sleeves. All sleeves shall be mechanically secured in place and sealed between the sleeve and structure. Apply firestop to the interior of the sleeve.
7. Loosely bundle cables within racks, ladder racks, cable trays and in discrete cable supports. Utilize reusable cable bundling hardware. Utilize plenum-rated hardware in plenum spaces.
8. Plenum-rated cable ties shall be used wherever wire ties are permitted and wherever plenum rated cable is used.
9. Cable ties shall never be used in a manner that causes deformation of the cable jacket, damage to the cable, or has any adverse effect on the usability, specifications or longevity of the cable(s) on which it is applied.
10. Velcro type wire ties shall be used in non-plenum spaces; in equipment racks; in rack cabinets, and; in related equipment housing enclosures and backboards.

**C. Cable Support**

1. All cables shall be supported/anchored every 5 feet (or less) and within 12" of device boxes, outlets, racks/cabinets and cable tray.
2. Use J-Hook type cable supports for all cables run outside of conduit or cable tray. Bridle rings shall not be used for Communications Technology cables.
  - a. Use separate J-Hook cable support systems for cables belonging to different systems and for cables carrying different operating levels. See Cable Separation guidelines in this section.
3. Loosely secure cables at each J-Hook.
4. Cables shall not be directly or indirectly supported by a suspended ceiling or any other surface, support, material or structure not permissible for this use by all applicable codes and standards.
5. Cable pathway
  - a. Use and positioning
    - 1) Pathway shall be installed to form a reusable pathway system.
    - 2) Totally enclosed raceways (i.e. conduit, wireway, etc.) shall be utilized to span in-accessible or working spaces (i.e. offices, classrooms, etc.).
    - 3) Cable trays and discreet cable supports shall be utilized to support cables.
      - a) To form an open-top reusable pathway
      - b) Shall be used in accessible ceiling cavities and areas not accessible by the public (i.e. mechanical and service areas).
      - c) Shall follow corridors unless specifically noted otherwise.

- d) Shall provide usable clearances above, below and beside for access space for the re-use of the pathway. Minimum 6" below and beside and 12" above.

**D. Cable Separation:**

1. Low-voltage cables shall be kept as far from electrical cables and equipment as possible. Avoid running low-voltage cables parallel to medium and high-voltage cables. When parallel runs cannot be avoided, keep low-voltage cables at least 24 inches away and cross cables at 90 degrees to minimize the risk of interference
2. Low-voltage cables shall not be permitted in the same conduit with high-voltage electrical cables.
3. Avoid running low-voltage cables any closer than 24 inches to any ballast type lighting fixture or other high RF energy producing device.
4. Cables for each system shall be installed separately and isolated from cables from other systems.
5. Cables carrying signals of different types and different nominal operating levels shall be kept separated to reduce the risk of undesirable interference and cross-talk between cables.
  - a. As a general rule, for each 25dBV difference in nominal operating level between cables, provide at least 6 inches of separation. Example 1: Cables with a 75dBV level difference between them shall be separated by 18 inches or greater. Example 2: Cables with a 13dBV difference between them shall be separated by 3 inches or greater.
  - b. Contractor shall provide additional separation to prevent and to remedy any crosstalk that adversely affects the performance and usability of the system, or that exceeds specific crosstalk performance guidelines defined elsewhere in these specifications.
  - c. Provide greater separation than this guideline where the contractor believes and/or determines it is necessary to prevent or remedy interference between cables.
6. Keep length of parallel runs to a minimum. Cross cables of different nominal levels at 90 degrees.
7. In common areas where cables from multiple systems are run in general proximity to one another, cables from each system shall be labeled to identify the system the cables serve.
8. Additional pathway devices/systems shall be provided as required to comply with cable separation requirements, including, but not limited to, conduits, sleeves, discrete pathway devices and cable tray.

**E. Cable Splices:**

1. Splices shall not be permitted in any cable except where expressly specified and/or approved by the Designer.
2. In cases where splices are specified and/or otherwise reviewed and permitted, splices shall be made within UL listed junction or device boxes. Open air connections shall not be permitted.

**F. Cable Terminations:**

1. Termination types shall correctly match cable and device termination. As an illustration, if "spade lug" type of termination is appropriate, then the spade lug cable entry size shall match the cable used. The spade lug shall also have the correct stud size to match the terminal to which it is connected. Terminations shall be completed with tools designed and sized for the specific application and connector.
2. Where field installed cables connect to manufactured products via pig-tails or connectorized cable assemblies, terminations shall be made within the product enclosure or within a UL approved box. Exposed and open air splices shall not be permitted.

**G. Strain Relief:**

1. Permanently installed cables shall be properly secured with an approved device. Strain relief shall be applied typically within 6 inches from the point of entry into a product enclosure, junction box, pull box, or device box. When properly applied, the strain relief device shall not damage the cable being secured and shall not permit movement of the cable in any way that may adversely affect the long-term integrity of nearby connections.

**H. Identification:**

1. General:
  - a. Identification shall be in English, except as otherwise noted.
  - b. Where identification is applied to surfaces that require a finish, install identification after the surface finish is applied.
  - c. Labeling products, color, sizes, nomenclature and location of the identification product are subject to the review of the Designer.
2. Cables:
  - a. Each cable shall be uniquely labeled at each end.
  - b. Labels shall be permanent and feature computer generated type-written text.
  - c. Label text shall be bold-type and clearly readable by a person with average sight, and under the lighting conditions typical within the area of installation.
  - d. Labels shall be applied approximately 4-6 cable-inches from the point of termination.
    - 1) Adjust application to make legible during service/maintenance of system.
  - e. Systems cables installed for "Future Use" shall be clearly identified as such at both ends. Such cables shall be labeled to identify where the opposite end of the cable can be found.
    - 1) Not applicable for Structured Cabling for voice/data connectivity.
  - f. Each cable installed shall be recorded on the as-built drawings.
3. Boxes:
  - a. Junction boxes and pull boxes shall be labeled on their interior and on their exterior covers with the identity of the system(s) the box serves along with the function of the box. Interior markings shall be made using permanent marker. Permanent marker may also be used on the cover of boxes installed in concealed areas (above accessible ceilings, for example). Exposed boxes shall be labeled with engraved plastic labels. Labels shall closely match the color of the box.
  - b. Device boxes, when first installed, shall be identified on its interior as to the system(s) served and the device(s) the box will contain.
    - 1) Where conduit feeding the device box is concealed, label the exterior of the conduit with permanent marker.
4. Equipment Racks, Cabinets, Enclosures:
  - a. Equipment racks and enclosures shall be labeled.
  - b. The nomenclature, color, size, installed location, and type of labels are subject to the Designer's review.
5. System Equipment:
  - a. Each individual instance of system equipment shall be labeled.
  - b. Front panel controls of equipment shall be labeled with nomenclature meaningful to the end user based on the intended use of the equipment in the system. Examples include, but are not limited to:
    - 1) Label router/matrix control panels with system specific input/output names.
    - 2) Label patch panels with meaningful input/output destination names.
    - 3) Label mixer input and output controls to identify the signal source and destination.
  - c. Professionally prepared, installed and readily visible "cheat sheets" may be acceptable under select circumstances with the approval of the Designer.
  - d. The nomenclature, color, size, installed location, and type of labels are subject to the Designer's review and approval.

- I. High Voltage Cabling (greater than 70.7 Volts):
  - 1. Cabling that carries voltages higher than 70.7 Volts RMS AC or DC shall be installed and terminated by persons licensed to perform such work.
- J. Plates and Panels:
  - 1. Box covers and faceplates shall be installed flush against the surface over which it is mounted. There shall be no visible gap between the backside of a plate/panel and the wall, ceiling or floor; there shall be no visible gap between the backside of plate/panel and a surface mount box to which the plate/panel mounts). Advanced craftsmanship and construction techniques shall be employed where necessary to achieve this.
    - a. The same shall apply to other wall and ceiling mounted products.
  - 2. Plates and panels shall be installed with all screw holes filled and fastened securely.
- K. Device Boxes, Pull-Boxes, Junction Boxes:
  - 1. Boxes installed in walls and ceilings shall be installed so that the box does not stand proud (protrude out beyond) of the finished surface. Boxes shall be installed such that when the mounted devices and cover plates are installed, the backside of the cover plate rests flush with the finished surface of the wall or ceiling. Advanced craftsmanship and construction techniques shall be employed where necessary to achieve this.

### **3.3 GROUNDING**

- A. Equipment shall be properly bonded to ground for the safety of personnel and property and as additionally necessary to satisfactory performance of the equipment.
- B. Comply with Section "Grounding and Bonding for Communications."

### **3.4 CUTTING, PATCHING AND SEALING**

- A. General:
  - 1. Perform cutting as required for the execution of the Work. Unless directed otherwise in the field, provide related patching and painting to match surrounding methods, materials and colors. Any damage caused during the progress of Work shall be remediated. Perform cutting, fitting, and patching and materials as required to:
    - a. Uncover Work to provide for installation of ill-timed Work.
    - b. Remove and replace defective Work.
    - c. Remove and replace Work not conforming to requirements of the Contract Documents.
    - d. Remove samples of installed Work as specified for testing.
    - e. Install equipment and materials within existing structures.
  - 2. Upon written instructions from the Owner's representative, uncover and restore Work to provide for observation of concealed Work by Owner's representative or by inspection by the Authority Having Jurisdiction.
  - 3. During cutting and patching operations, protect adjacent installations (e.g., structure, finishes, and furnishings). Where applicable, provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to system components and components of other trades.
  - 4. Patch surfaces and building components using new materials matching existing materials and using experienced Installers. Refer to Division 01 for definition of experienced "Installer" or determine qualifications as directed in the field by the Owner's representative.

5. Patching through fire rated walls and enclosures shall not diminish the rating of that wall or enclosure. Materials used for patching shall be installed to meet or exceed the smoke and fire rating of the respective surface being patched.
  6. Neatly cut and drill openings in walls and floors where openings are required for installation of the Work. Secure the approval of the Owner's Representative before cutting and drilling in existing facilities. Neatly patch any openings created.
  7. Cutting and patching shall be held to a minimum by arranging with other parties for sleeves and openings before construction is started.
  8. Provide factory-assembled watertight wall and floor seals, of types and sizes required, suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.
  9. Pipe sleeves shall be fabricated from Schedule 40 rigid, heavy wall, full weight galvanized steel pipe; remove burrs. Use sleeves which are two standard sizes larger than conduit passing through respective sleeve.
  10. Provide sleeve seals for piping that penetrates foundation walls below grade, or through exterior walls or roofs. Caulk between sleeve and pipe with non-toxic, UL-classified caulking material to ensure watertight seal. Elsewhere provide mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
  11. Install standard Schedule 40 black steel pipe sleeves two sizes larger than pipes passing through floors, bearing walls, fire walls and masonry construction. Furnish and set forms required in masonry walls or foundation to accommodate pipes.
- B. Grout:
1. Provide non-shrink, nonmetallic grout, pre-mixed, factory-packaged, non-staining, non-corrosive, and non-gaseous grout, recommended for interior and exterior applications.
- C. General Joint Sealer Application:
1. Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
  2. Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.
  3. Clean affected surfaces, joints, etc. immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.
  4. Apply sealant primer to substrates as recommended by manufacturer. Protect adjacent areas from spillage and migration of sealant, using masking tape. Remove tape immediately after tooling without disturbing seal.
  5. Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
  6. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
  7. Colors for exposed seals shall be as selected by the Owner's representative from manufacturer's standard colors.

**3.5 FIRESTOPPING**

- A. Penetrations created in support of any work of this Division shall be firestopped in accordance with locally applicable codes as acceptable to the Authority Having Jurisdiction.

**END OF SECTION 27 0501**

**SECTION 27 0503****SUBMITTALS FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Submittals shall be furnished for each Section that includes one or more of the following elements of work:
  - 1. Supply of one or more products.
  - 2. Installation of one or more products.
  - 3. Integration of one or more products.
  - 4. Programming of one or more products.
  - 5. Creation of one or more deliverable products.
  - 6. Labeling of one or more products.
  - 7. Testing of one or more systems.
  - 8. Contractor-based design or engineering of one or more products or systems.
- B. Additional Submittal requirements may be listed in the individual Specification Section(s) specific to that Section.

**1.2 SUBMITTAL TYPES**

- A. The following are the common submittal types referenced in this Section:
  - 1. Quality Assurance (QA).
  - 2. Product Data (PD).
  - 3. Shop Drawing (SD).
  - 4. Training (TG).
  - 5. Field Observation Response (FO).
  - 6. Key Drawings.
  - 7. Closeout Submittal (CO).

**PART 2 - PRODUCTS (NOT USED)****PART 3 - EXECUTION****3.1 GENERAL**

- A. Submittals shall be routed through established Project channels as identified by the Owner's representative.
- B. Coordinate, assemble, title, transmit and track Project submittals.
- C. Label each submittal of each type similarly for consistency and so they appear as if prepared by the same entity. Like-type submittals (e.g., Product Data) from different Sections shall feature the same appearance and organization as those of other Sections.



- D. Submittals prepared by subcontractors or vendors shall not be accepted unless prepared in compliance with the Contract Documents.
- E. Submittal items listed in this Section represent the common items required to be supplied for the various specification Sections throughout the duration of the Project. Individual Sections will vary and may include additional or lesser requirements.
- F. Designer reserves the right to require additional submittals or to waive select submittal requirements on a Section-by-Section basis. Additional submittals shall be provided at the Contractor's expense.
- G. The cost for preparation and transportation of submittals is Work of the Contract.
- H. Supply separate submittals for each Section. Do not combine multiple Sections together into a single submittal, except where expressly directed within the Contract Documents.
- I. Organize submittals as identified in the Contract Documents.
- J. Furnish submittals for different Sections each with its own transmittal form. A single transmittal shall not be used to identify submittals for more than one (1) Section at a time.
- K. Use of Electronic Drawings from the Owner's Design Team:
  - 1. If expressly permitted by the Owner and the terms of the Contract, editable electronic versions of standard-scale, AutoCAD-based plan drawings may be made available for the creation of shop and as-built drawings.
  - 2. Upon request when available, electronic versions of standard-scale, Navisworks (.dwf) and (.nwc) or AutoCAD 3D (.dwg) files may be made available for coordination purposes.
  - 3. Due to the proprietary nature of internal design systems, editable native-software versions of some drawings, including but not limited to system diagrams and details will not be made available in an editable form. In these cases, electronic versions of the drawings may be made available only in PDF, JPG or similar non-editable electronic form, at the sole discretion of the Design Professional.
  - 4. Revit files are not available.
  - 5. A "Request Drawings" form can be accessed, filled out and submitted at the following internet address <http://www.klhengrs.com> (right hand side of page - Contractor Resources). Direct access to this form can be found here: <http://files.klhengrs.com/requestdrawings.html>

### **3.2 SUBMITTAL SEQUENCE**

- A. Quality Assurance Submittal:
  - 1. When not expressly requested to be supplied with bid, the Quality Assurance submittal(s) shall be supplied upon request. When requested the submittal shall be delivered to the Designer within 16 business hours.
- B. Product Data Submittal:
  - 1. Submit following contract award or notice of intent to award a contract. Product data shall be submitted and reviewed prior to procurement of materials.

- C. Shop Drawing Submittal:
  - 1. Submit for review prior to commencement of fabrication and installation.
  - 2. Submit concurrently with Section-specific Product Data submittals.
- D. Training Submittal:
  - 1. Submit thirty (30) days prior to the first training session.
- E. Field Observation Report Submittal:
  - 1. Submit five (5) business days prior to punch list walkthrough.
- F. Closeout Submittal:
  - 1. Submit following completion of onsite work .

### **3.3 SUBMITTAL IDENTIFICATION**

- A. Identify each submittal uniquely.
- B. Identify each submittal by specification Section number, submittal type, and submittal iteration.
- C. The format for labeling the submittals shall be as follows:
  - 1. Section Number–Submittal Type Abbreviation–Submittal Iteration.
  - 2. Examples:
    - a. First Product Data Submittal for section 271513: “271513-PD-00.”
    - b. Revised Product Data Submittal for section 271513: “271513-PD-01.”
    - c. Second Revised Product Data Submittal for 271513: “271513-PD-02.”

### **3.4 SUBMITTAL CONTENTS**

- A. All Submittals:
  - 1. Transmittal:
    - a. Supply a dedicated transmittal for submittals for each individual Section.
    - b. Itemize the specific submittals included by Section, submittal type, and iteration.
  - 2. Title Sheet:
    - a. Include a separate title sheet with each submittal, of each type.
    - b. Title sheets for each Section, for each submittal type, shall have the same appearance.
    - c. Title sheets for product data submittals shall be 8-1/2 inches x 11 inches.
    - d. Title sheets for drawings shall be the same size as the associated drawings.
    - e. Create title sheets to have the appearance and information identified on the sample title sheet published at the end of this Section.
  - 3. Title Blocks:
    - a. Drawing submittals shall be created on the Contractor's, manufacturer's, or vendor's own title block. The title blocks of the Owner, Architect, Engineer, Designer or their Consultants shall not be reproduced on any document (electronic or hardcopy) that is prepared or altered by the Contractor.
  - 4. Legend:
    - a. Drawing submittals shall include a legend of symbology.
  - 5. Resubmittals:

- a. Resubmittals shall include a replica of the reviewer's comments that necessitated the resubmittal, along with an accompanying item-by-item explanation of the actions taken and changes that will be found within the resubmittal.
- B. Quality Assurance Submittals:
1. List of Subcontractors to be used on the Project along with a description of the role each will play on the Project.
  2. Proof of Quality Assurance compliance, as identified within Section 270002 "Quality Assurance for Communications" and in each individual Section.
- C. Product Data Submittals:
1. Bill of Materials (BOM):
    - a. Separate list for each system:
      - 1) When a Section covers products for use in multiple systems, supply separate BOM for each unique system covered by the Section. Label each with the system name, space/room name, and room number.
    - b. Include the following:
      - 1) Make, model, and description of each product.
      - 2) Quantity estimates for each product.
    - c. Organize the BOM to follow the order in which products appear within the Section.
  2. Product Datasheets Submittals:
    - a. Separate manufacturer datasheets for each product.
    - b. Datasheets shall be manufacturer original datasheet:
      - 1) Distributor modified, distributor branded, and/or html based "web" datasheets are not acceptable.
      - 2) Datasheets shall include size and technical support data.
    - c. Where manufacturer's datasheets depict multiple products, versions and options, indicate via highlighting, underlining, or with bold visible arrows the model(s), version(s) and option(s) being supplied. Exact catalog number(s) shall be indicated.
- D. Shop Drawing Submittals:
1. General:
    - a. Provide Drawings indicated in individual Sections as described below.
    - b. Drawing descriptions identify the required contents of common drawings required under the Contract.
    - c. Drawings identified within individual Sections, along with any additional drawings deemed necessary by the Designer, are required.
    - d. Drawing Scales:
      - 1) Floor plans shall be drawn to scale.
      - 2) Section drawings shall be drawn to scale.
      - 3) Elevation drawings shall be drawn to scale.
      - 4) Details of physical items shall be drawn to scale.
      - 5) Rack layouts and custom furniture drawings shall be drawn to scale.
      - 6) System drawings and schematic drawings shall be drawn 1:1 (no scale).
    - e. Sizes:
      - 1) Sheet sizes shall match the size of the Contract Drawings sheets, except where otherwise expressly requested or approved in advance by the Designer.
  2. Floor Plans:
    - a. Location of system devices and faceplates.
    - b. Labeling of outlets and devices.
    - c. Primary and secondary system cabling pathway(s).
      - 1) Coordinate for maximum length of cabling.

- d. Location of equipment racks.
  - e. Location of equipment enclosures.
  - f. Location of major system components.
3. Reflected Ceiling Plans:
  - a. Location of ceiling devices, coordinated with devices that are Work of others, and existing devices (where applicable).
4. System Diagrams:
  - a. Hybrid schematic / block wiring diagram.
  - b. System products depicted.
  - c. Product inputs, outputs and other ports depicted.
  - d. System cables depicted.
  - e. Product brand, model, description, options, and accessories declared.
  - f. Device.ID assignment for each product.
  - g. Interconnections depicted between system products.
  - h. Interconnections depicted between system products and related system products.
  - i. Declaration of the cable types, including brand, model, description and color. An accurate cable key is acceptable.
  - j. Unique identification (e.g., number) assignment for each cable.
  - k. Cable color coding schema.
  - l. Termination typicals, keyed to diagram interconnections.
5. Rack Elevations:
  - a. Absolute position of mounted components.
  - b. Device.ID, brand and model of each product.
  - c. Device.ID, brand and model of each power distribution product.
  - d. Size and type of each filler panel (vent and blank).
6. Custom Assemblies and Products:
  - a. Manufacturer.
  - b. Materials.
  - c. Finish and color(s).
  - d. Parts list.
  - e. Nomenclature sizes, colors.
  - f. Dimensions.
  - g. Schematic diagram(s), where applicable.
7. Termination Details:
  - a. Conductor-to-conductor, conductor-to-connector, conductor-to-terminal definitions of each product in the system. If typicals are used, they shall be accurately keyed to the system diagrams.
8. Power Distribution Diagrams:
  - a. Each power product.
  - b. Interconnectivity between power products.
  - c. Interconnectivity of local power distribution products to supply-side AC power.
  - d. Interconnectivity of system equipment to the power distribution system.
  - e. Circuiting and interconnectivity of power sequencer(s) and remote controlled power distribution systems.
  - f. Power-up and power-down sequence of products connected to the power distribution system.
9. Mounting Details:
  - a. Depicting the materials and means of securing installed products.
  - b. Finishes and colors of exposed parts.
10. Labeling Schema:
  - a. Organized methodical plan for the unique identification of cables within the system and for identifying cables from other systems.
11. Wall Elevations:

- a. Depict the location of products to be mounted on the walls, coordinated with Work of others, along with existing conditions (where applicable).
  - 12. Custom Furniture:
    - a. Manufacturer.
    - b. Dimensions.
    - c. Materials, finishes and colors.
    - d. Accessory parts.
    - e. Construction details.
    - f. Multiple views:
      - 1) Top, side, front and back, sections.
      - 2) Depicting the space allocation and products that the item is designed to accommodate.
- E. Training Submittals:
  - 1. Proposed schedule.
  - 2. Training agendas for each session.
  - 3. Identification of personnel that will conduct training.
  - 4. Handouts proposed for distribution during training.
- F. Field Observation Report Submittals:
  - 1. Written responses to Field Observation Reports supplied to the Contractor during the course of the Project:
    - a. The response shall include a copy of the original Field Observation Report.
    - b. The response shall include detail of the corrective action taken, the date the action was taken and the identity of the individual who took the action.
- G. Closeout Submittals:
  - 1. As-Built Drawings:
    - a. General:
      - 1) Requirements for Shop Drawings apply to "As-Built" drawings.
    - b. Required Drawings:
      - 1) Title Sheet.
      - 2) Floor Plans.
      - 3) System Diagrams.
      - 4) Power Distribution Diagrams.
      - 5) Rack Elevations.
      - 6) Communication Room Wall Elevations.
      - 7) Mounting Details.
      - 8) Custom Plate and Panel Assemblies.
      - 9) Patch Panel/Patch Bay Layouts.
      - 10) Labeling Schema.
      - 11) As-built version of each Project shop drawing.
    - c. Drawing Formats:
      - 1) Electronic Editable: Editable version using the native application used to create the file (e.g., Revit, AutoCAD, Visio).
      - 2) Non-Editable: PDF file format.
      - 3) Sheets shall be the same size and feature consistent title block information in the lower-right corner.
    - d. Drawing Organization:
      - 1) The first page of the set shall include a detailed index and sheet-by-sheet description of each drawing sheet.
  - 2. Test Reports and Checklists:

- a. Test reports, checklists, and other forms generated and completed during the course of the Project.
- 3. Operation and Maintenance Manuals:
  - a. Manual Contents and Organization:
    - 1) General:
      - a) Provide Manuals on solid state media (SD Card or USB "Thumb Drive) separate folders for each system, labeled.
      - b) Labeled sub-directories shall be created on the electronic media to label and separate contents for the manual.
    - 2) Project Information Cover:
      - a) Title of Project.
      - b) Name and address of Owner, Designer, Architect, Contractor of Record and Subcontractor.
      - c) System name and specification references.
    - 3) Index:
      - a) Contents of the manual.
    - 4) Warranty Statement:
      - a) A warranty statement shall be included for each system. The warranty statement shall reiterate the terms of warranty identified within the Contract Documents, as well as identify how the Owner is to obtain warranty service.
      - b) The warranty statement shall clearly identify which products are covered by Manufacturer warranties beyond the Contractor required minimum warranty period. The term of manufacturer warranty shall also be identified (e.g., 2 year parts and labor).
      - c) A separate warranty statement shall be supplied for each system.
      - d) Identify the date that the warranty for the system starts. This date shall be the date listed on the Certificate of Substantial Completion (if one was issued to the contractor specifically for the system) or the date listed on the Notice of Final Completion.
      - e) Supply standard out-of-warranty service rates and service contact information.
    - 5) Bill of Materials:
      - a) List of products supplied.
      - b) Serial numbers of each product.
      - c) IP addresses of those products configured to have static IP addresses.
      - d) MAC addresses of products featuring network communication ports (wired and/or wireless).
      - e) Network device names for those products configured for DHCP.
    - 6) Product Datasheets (supply only in the electronic version of Operation and Maintenance Manual):
      - a) Manufacturer datasheets for each product supplied.
    - 7) Manufacturer Owner / User Manuals:
      - a) Manufacturer's Owner's or User's manual for each product.
      - b) Manufacturer's Installation instructions and other documentation supplied with the product.
    - 8) Test Reports and Checklists:
      - a) Test reports, checklists, and other forms generated and completed during the course of the Project.
    - 9) Training Information:
      - a) Photocopy of training outlines / agendas.
      - b) Photocopy of training session handouts.
      - c) Photocopy of training sign-in sheets.

- d) Photocopy of signed delivery receipt for each training session recording (applicable to those Sections/systems requiring recording).
- 10) As-Built Drawings:
  - a) The electronic manual shall contain electronic PDF version of the as-built drawings.
- 11) Software (electronic manual only):
  - a) Editable configuration files for system equipment.
  - b) Software source code use in supplied products.
  - c) Compiled versions of configuration files and source code.
  - d) Software required for reviewing and editing supplied files.

### **3.5 SUBMITTAL QUANTITY**

- A. All Submittals:
  - 1. The quantity of submittals required shall be the greater of the following:
    - a. Quantity identified within Division 01.
    - b. Quantity identified within the individual Section.
    - c. Quantity identified herein.
  - 2. In addition to the Contract required quantity, the Contractor shall also submit any additional quantities required for its own use and records, and for distribution to other trades.
  - 3. The Designer shall retain a copy of each submittal received. Others in the submittal communication chain may also retain copies.
- B. Product Data Submittals:
  - 1. One (1) Electronic.
- C. Shop Drawings Submittals:
  - 1. One (1) Electronic.
- D. Training Submittals:
  - 1. One (1) Electronic.
- E. Field Observation Report Submittals:
  - 1. One (1) Electronic.
- F. Closeout Submittals:
  - 1. One (1) Electronic.

### **3.6 SUBMITTAL REJECTION**

- A. The following items are representative reasons that submittals may need to be revised and resubmitted:
  - 1. Binding submittals for multiple Sections together.
  - 2. Failing to supply separate transmittal for submittals for each Section.
  - 3. Failing to include a submittal title sheet.
  - 4. Failing to use and accurately complete the published title sheet.
  - 5. Failing to supply and accurately complete the submittal checklists.
  - 6. Failing to supply product data and shop drawings at the same time.
  - 7. Failing to include a detailed BOM with the product data.



8. Failing to supply product data sheets.
9. Failing to supply product data sheets with the correct product and required accessories enumerated.
10. Failing to supply shop drawings.
11. Failing to supply shop drawings with required information.
12. Failing to supply accurate information.
13. Failing to supply relevant information required by the Specifications.
14. Failing to supply products that are in compliance with the Specifications.
15. Failing to supply the required information in the required format.

### **3.7 RESUBMITTALS**

- A. Revise and Resubmit:
  1. When a submittal is rejected and flagged as "Revise and Resubmit," the entire submittal shall be reviewed, revised and resubmitted in totality.
  2. Resubmittals shall be checked for compliance with the Contract Documents, inclusive of requirements for submittals. In addition, any comments and deficiencies identified by the reviewer shall be appropriately acted upon.
- B. Exceptions Noted:
  1. When a submittal is flagged as "Exceptions Noted," the specific actions identified shall be taken.
  2. If the reviewer's comments include selective rejection of products, the resubmittal shall be limited to include those items commented upon.
- C. Resubmittals shall:
  1. Include a copy of the reviewer's previous comments.
  2. Include a written description of the action(s) taken.
  3. Be labeled chronologically.
  4. Be inclusive of all corrective action identified by the previous reviewer.

### **3.8 ELECTRONIC SUBMITTALS**

- A. Electronic submittals shall be the primary format for submission.
  1. Electronic submittal files shall be compatible for opening and viewing with electronic PDF file readers that fully support and recognize the Adobe PDF Portable Document Format Standard, version 1.5.
  2. Major text within the files shall be electronically searchable using the search-for-text features of current generation Adobe PDF reader software. Files shall be prepared in such manner that reviewers will have the option to search for and find words and phrases that appear within the document, electronically. Documents featuring raster-based text and text that is otherwise not searchable shall not be acceptable. This precludes the use of documents that have been electronically scanned and then converted to or embedded within an electronic file.
- B. The organization, contents, and labeling of information along with other requirements for submittals apply also to electronic versions of the submittals.
- C. Single File Submission:
  1. Option 1 – Single File, PDF Format:

- a. Single PDF file submittals shall be assembled from a series of individual files that are organized, indexed, bound together as one composite file that is bookmarked to aid the reviewer in navigating the content.
  - b. The file shall feature a navigational tree of contents, organized by content groups (e.g., Title Page, Index, BOM, Datasheets, Shop Drawings). Content groups shall be organized in the same relative order identified within the Contract Documents.
  - c. Within each content group shall be the supporting elements of the group (e.g., product datasheets under the Datasheets group). Each element of the content group shall appear separately as a subordinate element of the group (e.g., separate entry for each product datasheet, separate entry for each shop drawing), and viewable from the navigational contents tree.
  - d. Under the Datasheets content group, individual product datasheet entries shall be identified by Make/Brand and Model (e.g., Belden – 9451 – Audio Cable). Entries shall be organized in a sorted manner, first by make, then by model.
  - e. If the resulting size of the composite PDF file exceeds 10 Megabytes, supply the submittal using the Single Zip File method instead, as described in this Section.
  - f. The file name used to label the submittal shall be the section number followed by the submittal instance number for that Section (e.g., 271513-PD-01.pdf).
    - 1) Where the Designer directs the supply of multiple zip files for a submittal, add additional text to the file name to identify that the file is part of a multi-file set of submittals, as per the following examples:
      - a) 271513-PD-01 (1 of 3).pdf
      - b) 271513-PD-01 (2 of 3).pdf
      - c) 271513-PD-01 (3 of 3).pdf
2. Option 2 – Single File, Zip Format:
- a. Single Zip File submittals shall be assembled from a series of individual PDF files and file directories that are contained with a single compressed WinZip compatible “.zip” file.
  - b. The file shall contain separate top-level directories that are used to group related content (e.g., 00-Title Page, 01-Index, 02-BOM, 03-Datasheets, 04-Shop Drawings), with each directory appearing in the same relative order as that identified in the Contract Documents.
  - c. Within each content group directory shall be separate PDF-compliant files featuring the information required (e.g., separate datasheet file for each product, separate file for each drawing, separate file for each BOM).
  - d. Product datasheet files shall be named using a consistent naming convention that enables those files to appear sorted and grouped when the file is opened for navigation, viewing or extraction by the reviewer.
  - e. Product datasheet files shall be consistently named with the make/brand of the product, followed by model number, followed by any additional information beneficial (e.g., Belden – 9451 – Audio Cable).
  - f. Consult the Designer for supplement instructions should the WinZip file exceed 50 Megabytes in size.
  - g. The file name used for the submittal shall be the Section number followed by the submittal instance number for that Section (e.g., 271513-PD-01.zip).
    - 1) Where the Designer directs the supply of multiple zip files for a submittal, add text to the file name that identifies the file is part of a multi-file set as per the following examples:
      - a) 271513-PD-01 (1 of 3).zip
      - b) 271513-PD-01 (2 of 3).zip
      - c) 271513-PD-01 (3 of 3).zip

**END OF SECTION 27 0503**

SUBMITTAL TITLE SHEET

EXAMPLE

(Form: Sub-1)

PROJECT TITLE:

Project Name Line 1

Project Name Line 2

Project Name Line 2

SUBMITTAL TYPE:

Product Data

SECTION SUBMITTAL NUMBER

271116-PD-00

SECTION TITLE:

Cabinets, Racks, Frames  
and Enclosures

Date Prepared:

yyyy-mm-dd

CONTRACTOR OF RECORD:

Firm Name

Address 1

Address 2

City, State, Zip

Phone (000) 000-0000, Fax (000) 000-0000

Project Manager: Full Name

PM E-Mail: [xxxxxxxx@xxxx.xxx](mailto:xxxxxxxx@xxxx.xxx)

SECTION SUBCONTRACTOR(S):

Firm Name Address 1 Address 2 City, State Zip Phone (000) 000-0000 Fax (000) 000-0000 PM Name: Full Name PM E-Mail: xxxxxxxxx@xxxx.xx	Firm Name Address 1 Address 2 City, State Zip Phone (000) 000-0000 Fax (000) 000-0000 PM Name: Full Name PM E-Mail: <a href="mailto:xxxxxxxxxx@xxxx.xx">xxxxxxxxxx@xxxx.xx</a>
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**SECTION 27 0505****DEMOLITION & EXISTING CONDITIONS FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Requirements relating to existing conditions, demolition, removal, and reinstallation of existing work installed at the project site.

**1.2 EVALUATION OF EXISTING CONDITIONS**

- A. Prior to submitting pricing for Work of this Division, perform an inspection of existing conditions. Inspection shall include applicable accessible ceiling cavities, limited access areas, and systems.
1. Should the Contractor take exception to furnishing any demolition or new Work, such exception(s) shall be submitted to the Designer during bidding so that they can be addressed via Addendum.
  2. No consideration shall be afforded the Contractor after bid for failing to adequately estimate sufficient allowances for Work that could have been estimated more sufficiently prior to bidding.
  3. Existing communications Work is shown to a limited extent on the Drawings and is shown for general planning and reference only. It is not the intent of the Contract Documents to accurately show existing conditions. Device and system locations are indicated based on cursory visual observations and/or from portions of Contract Documents prepared for previously installed work (not from "as-builts"). These locations are not guaranteed. The successful Contractor shall have access to any available existing building/system plans and specifications.
- B. Unless specifically noted otherwise within the Contract Documents, new devices shall be provided. The existing wiring systems may be utilized only to the extent indicated within the Contract Documents and/or as directed by the Owner's representative in field.
- C. Prior to commencing Work of this Division, Contractor shall document initial existing conditions of equipment and ancillary devices, controls or cabling to be reused. If documentation is not provided prior to commencing work indicating non-working condition of equipment, ancillary devices, controls or cabling, Contractor shall bear the costs of replacement or repair of equipment, ancillary devices, controls or cabling.

**1.3 EFFECT ON ADJACENT OCCUPIED AREAS**

- A. Locate, identify, and protect communication services, systems and cabling passing through demolition areas and serving other areas outside the demolition limits.
- B. Maintain communications services and systems to areas outside demolition limits. When services or systems must be interrupted, install temporary services for affected areas.

- C. Some wiring and/or conduit systems may be rendered inactive by demolition, causing disconnection of downstream outlets. Investigate and document similar conditions for every system prior to demolition. Provide necessary corrective Work, including, but not limited to, wiring and connections, prior to demolition to ensure that downstream devices remain permanently active throughout demolition, new construction and after project completion.
- D. Coordinate Work and system shutdowns in advance with the Owner's representative and affected trades so that normal building and staff functions and other construction trades are minimally affected. Any demolition and/or new construction Work that may affect occupied areas, including those which are located outside the immediate area of project Work, shall be performed at special times as directed by the Owner's representative in the field.
- E. Existing systems and components shall remain fully operational in occupied spaces during occupied periods.

#### **1.4 PROTECTION OF ADJACENT WORK**

- A. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust, dirt and debris to adjacent finished areas and/or other system components. During cutting and patching operations, protect adjacent installations. Remove protection and barriers after demolition operations are complete.

#### **1.5 PRE-EXISTING CODE VIOLATIONS**

- A. If any code or safety violations are discovered, they shall be immediately detailed in writing and brought to the attention of the Owner's representative along with the proposed cost for corrections and impact (if any) on the construction schedule.

#### **1.6 GENERAL DEMOLITION**

- A. Perform cutting and patching required for demolition in accordance with Division 1 Section "Cutting and Patching."
- B. Coordinate Work with the Owner prior to beginning communications demolition Work. Unless directed otherwise in the field, abandoned systems cables shall be disconnected at both ends and removed back to their respective sources, even if sources are outside of the boundaries of the project area.
- C. Provide demolition for communications systems Work throughout the project area(s). Unless specifically noted on the Drawings, or determined during a pre-demolition survey, abandoned existing communications work in the project area(s) shall be disconnected and removed in its entirety. Related Work shall comply with the notes identified within the Contract Documents.
- D. Provide demolition to clear and remove existing communications Work that is to be abandoned and as required to accommodate new Work of every trade.
- E. Remove abandoned, inactive and obsolete wiring, equipment and devices.

1. Abandoned conduits shall be cleared back to the source(s), including sources that are outside of the boundaries of the project area.
  2. Abandoned systems cables shall be disconnected at both ends and removed back to the source(s), including sources that are outside of the boundaries of the project area.
- F. Abandoned penetrations through floors or wall shall be sleeved and firestopped to a level equal to or greater than the original fire rating of the structure.
- G. Wiring and devices conflicting with construction related Work of any trade shall be removed and/or relocated as necessary and/or as directed by the Owner's representative in the field. Communications disconnections and/or reconnections for equipment to be removed and/or relocated by other trades shall be made as Work of this Section. This applies to existing communications Work whether shown on the Drawings or not.
- H. Extend wiring, as required, to accommodate new or relocated communications Work.
- I. For existing wiring or cabling to remain, provide a split-sleeve assembly through the new wall and ceiling construction to route the existing wiring or cabling. Provide firestopping split-sleeve assemblies through rated walls and ceilings.

#### **1.7 DISPOSITION OF REMOVED EQUIPMENT**

- A. Abandoned materials removed during demolition shall be referred to the Owner's representative for disposal instructions. Materials that the Owner elects to retain shall be neatly stored at the site, as designated by the Owner's representative. Lawfully dispose of materials that the Owner elects not to retain. Additional costs incurred due to the disposal of demolished items shall be the responsibility of the Contractor.
- B. Devices or equipment designated for salvage, removal and reuse, or for turning over to the Owner shall be disconnected and removed undamaged. Remove related abandoned wiring back to the nearest "upstream" active junction box (field verify). Dedicated wiring shall be removed back to the source. Disconnect wiring and whips from equipment terminal points, and carefully transport and neatly store within a protected on-site storage location as directed in field.
- C. The following applies to communications devices and equipment that is to remain or be reused for the Project:
1. Protect during demolition and construction.
  2. Clean and service (if service is required) immediately prior to occupancy of the area.
  3. If required to accommodate construction related activities, remove and reinstall equipment and devices that are to remain.
  4. Equipment and devices that require temporary removal shall be neatly stored in a protected area until re-installed.
  5. Components to be reused shall be cleaned (inside and out) and reinstalled where indicated on drawings. Modify and/or extend related existing wiring as required. Transport components turned over to Owner to a designated location on site and neatly store by system type.

**PART 2 - PRODUCTS**

**2.1 NOT USED**

**PART 3 - EXECUTION**

**3.1 NOT USED**

**END OF SECTION 27 0505**



**SECTION 27 0528****PATHWAYS FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Raceway.
  - 2. Innerduct.
  - 3. Spillways/waterfalls.
  - 4. Floor boxes.
  - 5. Device boxes.
  - 6. Cable spillways.
  - 7. Discrete cable supports.
- B. Shop Drawings:
  - 1. Coordinated floor plan drawings depicting the size(s), locations, and dimensions of the following:
    - a. Primary pathways.
    - b. Conduit sleeves (e.g., thru-the-wall, thru-the-floor, and thru-the-bulkhead).
    - c. Roof penetrations.
    - d. Conduits: Trade-size 2 inches and larger.
    - e. Raceway: Featuring a cross-sectional area of  $\geq 4$  square inches.
    - f. Vertical and horizontal working clearances around tray and ladder rack.
  - 2. Conduit Interconnect Diagrams: for each totally-enclosed pathway system.
- C. Closeout Submittals:
  - 1. Accurate up-to-date as-built versions of shop drawings.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Hybrid Pathway System: A pathway system built from a varied mixture of boxes, raceway, cable tray and discrete cable supports. Fundamentally a pathway system that is not a totally-closed pathway system. A hybrid pathway system supports cables in the horizontal at increments not exceeding 60 inches.
  - 2. Pathway: A collection of products that when used together achieve a complete means for the conveyance of cable(s) from one location to another. A pathway system protects and supports cables to various degrees depending upon the application and products used. The pathway system most frequently terminates into an enclosure, boxes or other apparatus where cables are terminated and associated devices are mounted.
  - 3. Primary Pathway: A cabling pathway typically located in a corridor, public area, or dedicated vertical cable chase and used to enclose and/or support large quantities of compatible-signal cables from one or more systems to the general vicinity of where cables are terminated. Cables carried by a primary pathway transfer to secondary pathways.
  - 4. Raceway: An enclosed pathway component used for the routing of cables. The raceway envelops the cables that pass through it to protect them from physical damage, and at

times from heat, humidity, corrosion and water intrusion. A raceway may feature a continuous outer shell, or in select cases (such as surface raceway) may feature a removable outer shell that facilitates installation and removal of cables. Raceway frequently terminates directly into boxes or enclosures used for the purpose of mounting devices and termination of the cables.

5. Secondary Pathways: Pathways typically branching from a primary pathway and routing to a space(s) where a cable is terminated. A secondary pathway typically accommodates sixteen (16) cables or less. A secondary pathway carries cables from a single system that together can be run in tight parallel proximity to one another without any negative impact on adjacent cables or cause distortion or induce consequential interference on the signals they carry.
6. Totally Enclosed Pathway System: A pathway system that is built from a mixture of boxes and raceway that when assembled are closed on all sides. Fundamentally it is a pathway system where the cables within the system are not visible and not accessible except when a component of the system, or a device mounted to it is removed. A totally enclosed pathway system supports cables run horizontally and continuously.

### **1.3 SPECIAL REQUIREMENTS**

- A. Contract Division of Work and issuance of separate contracts notwithstanding, the entity(s) performing work of this Section shall have the responsibility to provide complete, working and code compliant pathway systems for the systems specified in this Division and for the additional systems so specified in the Contract Documents. Such systems shall be constructed in compliance with the Contract Documents.
- B. Provide complete, working and code compliant pathway systems for Division 27 and Division 28 Systems (where applicable), and as otherwise identified in the Contract Documents. Note that the Drawings may not fully detail the required complete pathway system and components.
- C. Should Work of this Section be performed by a party that is different from the party responsible for providing components (e.g., cabling) that utilize the pathway systems, the pathway provider shall:
  1. Review specifications of this Division and Division 28 Systems (where applicable) and the related Drawings to gain a complete understanding of the specific systems that will utilize the pathways.

### **1.4 SYSTEM DESCRIPTION**

- A. General:
  1. Each communications pathway system shall consist of products to support, protect, enclose, manage and secure the cables that are part of the communication system they serve.
  2. Pathway systems shall be supplied and installed to meet the unique requirements of individual communications systems.
  3. Separate pathway systems shall be provided for individual communication systems. Individual communication systems shall have unique and dedicated conveyances. Cables from individual communication systems shall be run in separate conveyances (e.g., data system cables shall be run in separate conveyances from sound system cables).
  4. Separate pathway conveyances shall be provided for cables that carry incompatible signal types (e.g., analog microphone level and speaker level cables shall be run in separate conveyances).

5. Pathway systems shall include penetrations through walls, floors, ceilings, roofs, bulkheads and other physical barriers that are necessary to route cable between adjacent spaces.
  6. Pathway penetrations shall be prepped, installed, sealed and fire stopped in a code-compliant manner.
  7. Pathways through expansion joints shall include expansion and deflection joint fittings with bonding straps.
  8. Pathways shall be assembled from components that are listed by a recognized safety testing laboratory.
  9. The cable fill capacity of each pathway segment shall meet or exceed the capacity necessary to accommodate cables initially installed. Additional capacity shall be provided as identified in the Contract Documents. The sizes and quantities of conveyances shown on the Drawings shall be interpreted as minimums. Larger sizes, or additional quantities, shall be provided as required or further identified herein.
  10. Pathway systems shall be provided with sufficient support to carry the weight of the system, plus a full capacity of cables, with a safety factor of greater than or equal to 5. In addition, each individual above-the-floor vertical hanging support shall feature an installed static weight support capacity of not less than 200 lbs. (e.g., hanging all-thread, multi-anchor mounting flange and support cable).
  11. Pathway systems shall include matching cover plates over junction and pull boxes.
- B. Pathway Systems for Horizontal Copper, Coaxial and Fiber Cabling:
1. Totally enclosed raceway system.
  2. Minimum permissible conduit size: ¾-inch.
- C. Pathway Systems for Audio and Video Systems:
1. Totally enclosed raceway system .
  2. Minimum permissible conduit size: 3/4-inch.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.

### **2.2 RACEWAY**

- A. Conduit:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Hubbell-Raco (Raco).
    - b. Allied Tube & Conduit / Atkore (Allied).
    - c. Republic Conduit (Republic).
    - d. CalConduit (CalConduit).
  2. Rigid Steel Conduit (RMC):
    - a. NEC Type RMC recognized.

- b. Threaded rigid steel conduit shall be manufactured from mild steel, zinc galvanized both inside and outside including threads.
  - c. Constructed in accordance with ANSI C80.1, Underwriters Laboratories Safety Standard UL6.
- 3. Intermediate Metallic Conduit (IMC):
  - a. NEC Type IMC recognized.
  - b. Threaded intermediate metallic conduit shall be manufactured from mild steel, zinc galvanized both inside and outside including threads.
  - c. Constructed in accordance with ANSI C80.6, Underwriters Laboratories Safety Standard UL6.
- 4. Electric Metallic Tubing (EMT):
  - a. NEC Type EMT recognized.
  - b. Electric metallic tubing shall be manufactured from mild steel, zinc galvanized both inside and outside.
  - c. Constructed in accordance with ANSI C80.2, Underwriters Laboratories Safety Standard UL6.
- 5. Flexible metallic conduit (FMC):
  - a. NEC Type FMC recognized.
  - b. Spirally wound double sized zinc galvanized steel.
  - c. Unjacketed.
  - d. Integral ground conductor.
  - e. Color: Natural zinc.
- 6. Liquid-Tight Flexible Metal Conduit (LFMC):
  - a. NEC Type LFMC recognized.
  - b. Spirally wound double sized zinc galvanized steel.
  - c. Overall liquid-tight outer jacket.
  - d. Integral ground conductor.
  - e. Color: Gray.
- 7. Polyvinylchloride (PVC-A, PVC-B):
  - a. Constructed of Type C300 virgin polyvinylchloride.
  - b. Schedule 40 or Schedule 80 rated to 90°C.
  - c. Constructed in accordance with NEMA TC2 and Federal Specifications W-C-1094A.
- 8. Conduit LB
  - a. Built in bend radius to protect cabling
  - b. Madison Electric Products Smart LB

## **2.3 DISCRETE CABLE SUPPORTS**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into work include:
  - 1. Erico CableCat™ Series.
  - 2. Panduit J-Pro™ Series.
  - 3. Cooper/B-Line BCH Series.
- B. Product Requirements:
  - 1. UL 2043 Listed and NEC compliant for use in plenum air returns.
  - 2. J-Hook style design.
  - 3. No sharp edges that could come in contact with supported cables during or after installation.
  - 4. Linear bearing surface for cable:
    - a. For use with backbone cables: Greater than or equal to 1-3/4 inches.
    - b. For use in primary pathways: Greater than or equal to 1-3/4 inches.
    - c. For use in secondary pathway: Greater than or equal to 1-3/8 inches.

- d. For use with individual cables less than 0.400 inch diameter: Greater than or equal to 7/8 inch.

## **2.4 FITTINGS**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Hubbell-Raco (Raco).
  - 2. Allied Tube & Conduit / Atkore (Allied).
  - 3. Republic Conduit (Republic).
  - 4. CalConduit (CalConduit).
  - 5. Cooper Crouse Hinds.
- B. Rigid Steel or Intermediate Metallic Conduit:
  - 1. Threaded to NEMA standards for conduit.
  - 2. Integral non-conductive plastic throat liner to minimize/eliminate risk of cable abrasion during installation.
  - 3. Zinc galvanized steel.
  - 4. Conductive.
- C. Electric Metallic Tubing:
  - 1. Compression type.
  - 2. Integral non-conductive plastic throat liner to minimize/eliminate risk of cable abrasion during installation.
  - 3. Attachment: 100-percent concentric compression.
  - 4. Zinc galvanized steel.
  - 5. Conductive.
- D. Flexible Metallic Conduit:
  - 1. Fittings shall be manufactured by the same manufacturer as the raceway(s) it connects.
  - 2. Integral non-conductive plastic throat liners to minimize/eliminate risk of cable abrasion during installation.
- E. Polyvinylchloride (PVC-A, PVC-B):
  - 1. Fittings shall be manufactured by the same manufacturer as the raceway(s) it connects.
  - 2. Seal connections using PVC cement.
- F. Conduit Sealing Bushings:
  - 1. Factory-fabricated watertight conduit sealing bushing assemblies.
  - 2. Suitable for sealing around conduit or tubing passing through concrete floors and walls.
  - 3. Constructed of steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- G. Insulating Bushings:
  - 1. Designed to protect cables from damage caused by sharp edges on the exposed end(s) of conduit and associated fittings, fully insulating the exposed end.
  - 2. Rated for use in the environment where the product is installed.
  - 3. Sized to match the conduit or conduit fitting to which it is applied.
  - 4. Soft radius non-conductive front edge to prevent damage to cables passing through the bushing.

5. Sized to hold firmly to the conduit or fitting to which it attaches with sufficient strength that the bushing cannot and will not come free during the installation of cable.
  6. Non-conductive version:
    - a. Threaded version: Provide threaded version for use on the threaded end of conduits or fittings.
    - b. Press-on version: Provide press-on version for use on non-threaded end of conduits and conduit fittings.
    - c. Internal diameter of one end equal to or slightly less than the internal diameter of the conduit or fitting to which it attaches. The opposite end sized to match the conduit or fitting to which it is applied.
    - d. Designed for installation before any cable is installed.
  7. Conductive version:
    - a. Conductive metal frame.
    - b. Integral grounding lug.
    - c. Separate non-conductive insulator to protect cable.
    - d. Designed for installation before any cable is installed.
- H. Expansion/Deflection Fittings:
1. Shall provide 4" axial expansion/contraction
  2. Shall allow  $\frac{3}{4}$ " parallel misalignment
  3. Shall allow up to 30 degree angular misalignment in any direction
  4. Basis of Design shall be Cooper Crouse Hinds:
    - a. 2" Expansion/Deflection joint fitting XJGD64 (Galv. Rigid Conduit)
    - b. Tinned copper Braid Bonding Jumper 24" BJ64
    - c. 2.5" Expansion/Deflection joint fitting XJGD74 (Galv. Rigid Conduit)
    - d. Tinned copper Braid Bonding Jumper 24" BJ74
    - e. 3" Expansion/Deflection joint fitting XJGD84 (Galv. Rigid Conduit)
    - f. Tinned copper Braid Bonding Jumper 24" BJ84
    - g. 4" Expansion/Deflection joint fitting XJGD104 (Galv. Rigid Conduit)
    - h. Tinned copper Braid Bonding Jumper 36" BJ108

## **2.5 PENETRATIONS**

- A. All penetrations through walls, floors, and ceilings shall be sleeved.
1. Reference Firestopping for Communications specification for fire rated sleeve assemblies.
  2. All sleeves shall be metallic and shall have bushings at both ends.

## **2.6 BOXES**

- A. Standard Wall and Ceiling Device Boxes:
1. General:
    - a. Stamped steel, code-compliant gauge, zinc galvanized.
    - b. Available in various depths from 2-1/2 to 3-1/2 inches deep, minimum.
    - c. Corrosion protection suitable for the atmosphere in which they are installed.
    - d. Non-modular sheet-steel construction.
    - e. Conduit knockouts of the size, quantity and locations required.
    - f. Threaded device-mounting screw holes.
    - g. Rated for installation in the space where the box is installed.
    - h. Equip boxes with code compliant accessory Class-1 and Class-2 service partitions when boxes are used in multi-service applications.
  2. Boxes in Masonry or Tile Walls:
    - a. "Masonry" style box construction.

- b. Available in standard gang sizes from 1 to 10.
      - c. Available in various depths from 2-1/2 inches to 3-1/2 inches.
      - d. Conduit knockouts to suit the application.
    - 3. Boxes used within interior framed walls (e.g., gypsum board walls):
      - a. 1 to 2 Gang Sizes, 2-1/2 inches box depth:
        - 1) 4 inches square or 4-11/16 inches square box, 2-1/8 inches deep.
        - 2) 3/4" deep device ring (single or double as required).
      - b. 3 to 10 Gang Sizes:
        - 1) Multi-gang style box construction (not gangable), 2-1/2" depth.
        - 2) 3/4" deep device ring.
        - 3) Conduit knockouts to suit the application.
- B. Exterior Surface Mount Outlet Style Boxes:
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Adalet / Scott Fetzer Company (Adalet).
  - 3. Appleton Electric (Appleton).
  - 4. Characteristics:
    - a. Hinged cover, sized to accommodate the devices being mounted to the box.
    - b. Cast aluminum construction.
    - c. Available in standard gang sizes from 1 to 3.
    - d. Threaded conduit hubs.
- C. Junction Boxes and Pull Boxes:
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Hubbell-Raco (Raco).
    - b. Allied Tube & Conduit / Atkore (Allied).
    - c. Republic Conduit (Republic).
    - d. CalConduit (CalConduit).
    - e. Hoffman.
  - 2. Characteristics:
    - a. Screw-cover type enclosure.
    - b. Covers fabricated of the same material and with the same finish as the box itself.
    - c. Boxes installed flush in wall shall be provided with oversize cover plates painted to match the surrounding building surface.
    - d. Boxes shall be NEMA rated for the atmospheric condition in which the box is installed.
    - e. Boxes in exterior or moist locations shall meet NEMA 3R (at minimum).

## **2.7 ACCESSORIES**

- A. Pull Strings:
  - 1. Construction: nylon.
  - 2. Designed and rated by the manufacturer for use as a pull-rope.
- B. Fiber Optic Innerduct:
  - 1. Manufacturers: Subject to compliance with requirements, provide the Basis of Design product listed, or Designer approved comparable product from:
    - a. Arnco.



- b. Endot.
    - c. Opti-Com.
    - d. Pyramid.
  - 2. NEMA TC 5, UL listed, corrugated, specifically designed for optical fiber cable pathways.
    - a. Color: Orange.
    - b. 1-inch minimum inside diameter.
    - c. 600 pounds minimum pulling strength.
    - d. Factory installed pull rope.
    - e. UL Listed and NEC approved for the environment in which it is installed.
    - f. Basis of Design:
      - 1) Riser Rated Environments: Carlon DF4X1C-\*\*\*\*.
      - 2) Plenum Rated Environments: Carlon CF4X1C-\*\*\*\*.
- C. Cable Waterfalls (Spillways) – for Conduit:
  - 1. Manufacturers: Subject to compliance with requirements, available manufactures offering products that may be incorporated into Work include, but are not limited to, the following:
    - a. Bejed, Inc.
    - b. LincTek, Inc.
    - c. Cooper/B-Line.
    - d. Chatsworth.
    - e. Cable Management Corp.
    - f. Panduit
  - 2. Product Requirements:
    - a. Available in 2 inches and 4 inches diameter for direct attachment to conduit stubs and sleeves.
    - b. Integral clamp for securing to EMT conduit.
    - c. Maintains proper bending radii for cabling entering the conduit served.
    - d. Self-fastening tie down system.
    - e. UL Listed and NEC approved for the environment in which it is installed.
- D. Supports:
  - 1. General:
    - a. Supports, support hardware, and fasteners shall be manufacturer protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic.
    - b. Products used outdoors shall be hot-dip galvanized.
  - 2. Material Types:
    - a. Raceway Supports:
      - 1) Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
    - b. Fasteners:
      - 1) Types, materials, and construction features as follows:
        - a) Expansion anchors: Carbon steel wedge or sleeve type.
        - b) Toggle bolts: All-steel springhead type.
        - c) Powder-driven threaded studs anchors: Heat-treated steel, designed specifically for the intended service.
        - d) Solid concrete anchors: Drop-in zinc plated steel tubular expansion shield with solid, cone-shaped expander plug.
    - c. Cable supports for vertical conduit:
      - 1) Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits.
      - 2) Provide with plugs with the number and size of conductor gripping holes as required to suit each individual application.

- 3) Body construction: Malleable-iron casting with hot-dip galvanized finish.
- d. Threaded Rod Stock (All-Thread Rod):
  - 1) Available in 1/4-inch, 3/8-inch, 1/2-inch, and 5/8-inch sizes.
  - 2) Utilize 1/2 " for ladder/tray installations under 24" and 5/8" for 24" or larger.
    - a) Rod lengths over 6' will require a "Rod Stiffener" installation for 1/2" and 5/8" rods.
- e. Slotted Metal Angle and U-channel Systems:
  - 1) 16-gauge steel U-shaped channel;
  - 2) Available in a variety of sizes including: 1-5/8 inches square, 1-1/4 inches square and 13/16 inch square.
  - 3) Available with pre-punched and un-punched versions.
  - 4) Available with holes on top or sides of channel.
  - 5) Available with a wide-variety of fittings for field construction of structural support assemblies.
- E. Bushing, Knockout Closures and Locknuts:
  - 1. Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.
- F. Pipe Curb Assemblies:
  - 1. Manufacturers: Subject to compliance with requirements, available manufactures offering products that may be incorporated into the Work include, but are not limited to:
    - a. The Pate Company, PCC-series.
  - 2. Product Requirements:
    - a. Designed to seal around pipes penetrating through conventional or metal roofs.
    - b. Prevents the ingress of water into the building under all weather conditions.
    - c. Models available to accommodate all standard sizes or pipe from 1/2 inch to 10 inches O.D.
    - d. Stainless steel pipe fasteners.
    - e. Provide with manufacturer recommended accessories and options necessary to seal and prevent water infiltration.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Review and coordinate the size requirements of pathways with the suppliers and installers of cabling and devices. Pathway segments shall accommodate the quantity and type of cables that will be installed. Upsize pathway segments from any default and minimum size(s) identified so as to accommodate the cables that will be installed, including any future expansion capacities, as identified in the Contract Documents.
- B. Review the specific routes and composite length of planned pathway routes with parties responsible for supplying or installing cables as distance limitations will apply differently for different cables and applications.
- C. Coordinate the location and routing of pathways with work of this Division, the work of other trades, the work of the Owner, and existing site conditions (where applicable) to ensure adequate headroom, post installation access to and working clearances around the pathways. Review and

verify HVAC, Fire Suppression, Electrical Power, Lighting and other Drawings for design coordination. Provide routes accordingly.

- D. Proactively participate with other trades in the creation of coordination drawings that depict primary and major secondary pathways. Emphasis shall be placed on ensuring that pathways are accessible for initial cable installation and readily accessible for reuse in accommodating future cable moves, additions and changes.
- E. Coordinate the colors and types of surface raceway with the color of surface raceway provided as work of both Division 26 and Division 28. Colors of raceways shall match, except where expressly reviewed and approved by the Architect/Designer.
- F. Ensure that pathways, as installed, are adequately sized for the cables to be installed and any future expansion capacities as identified in the Contract Documents.

### **3.2 GENERAL**

- A. Provide specified pull wires in all cabling pathways.
- B. Ground and bond all systems in accordance with the NEC and ANSI/TIA/EIA 607.
- C. All installation material and practices shall fully comply with NFPA 70 "National Electrical Code" and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces.
- D. Coordinate work with the building structural systems and electrical installation.
- E. All work shall fully comply with these Specifications and related Drawings and all manufacturers' recommended installation practices.

### **3.3 PATHWAY SIZING**

- A. Raceways shall be sized so that they are the larger of the following:
  - 1. Minimum size indicated within the Contract Documents.
  - 2. In accordance with the National Electric Code.
  - 3. As recommended by the product manufacturer.
- B. Discrete cable supports shall be sized so that they are the larger of the following:
  - 1. Minimum size indicated within the Contract Documents.
  - 2. In accordance with the National Electric Code.
  - 3. As recommended by the product manufacturer.

### **3.4 RACEWAY USAGE**

- A. Rigid Steel (GRC) Conduit:
  - 1. Above grade, outside the building envelope, in exposed areas.
  - 2. Above grade, inside the building envelope, within high moisture areas.

3. As a transitional component of a below grade conduit path where the conduit needs to pass through a poured-in-place concrete slab.
  4. As a sleeve through poured-in-place concrete slabs.
  5. Where specifically indicated on the Drawings.
- B. Intermediate Metallic Tubing (IMC) Conduit:
1. Where specifically indicated on the Drawings.
- C. Electric Metallic Tubing (EMT) Conduit:
1. Within the building envelope concealed within walls and ceilings.
  2. Above grade, inside the building envelope, where no other type of raceway is identified to be used.
  3. Where specifically indicated on the Drawings.
- D. Flexible Metal Conduit (FMC):
1. Inside the building envelope as a component of a secondary pathway system where flexibility is necessary for constructability to meet specified objectives and where length of the segment does not exceed 6 feet.
  2. Inside the building envelope as the transitional segment of a raceway system and interconnection to permanently-cabled systems-furniture is necessary and where the length of the FMC segment does not exceed 12 feet.
  3. Where specifically indicated on the Drawings.
- E. Liquid-Tight Flexible Metal Conduit (LFMC):
1. Above grade, outside the building envelope, between junction (or pull) boxes and connected devices (e.g., cameras) and where cables to/from the devices would otherwise be visually exposed or exposed to the elements.
  2. Above grade, outside the building envelope, between junction (or pull) boxes and connected devices requiring regular movement where cables to/from the device would otherwise be visually exposed or exposed to the elements.
  3. Above grade, inside the building envelope, between junction (or pull) boxes and connected devices (e.g., cameras) and where cables to/from the connected devices would otherwise be exposed to water or sustained periods of high moisture.
  4. Above grade, outside the building envelope, between junction (or pull) boxes and connected devices requiring regular movement where cables to/from the device would otherwise be exposed to water or sustained periods of high moisture.
  5. Where specifically indicated on the Drawings.
- F. Polyvinylchloride (PVC) Conduit:
1. Below grade, where conductive conduit is not otherwise required.
  2. Where specifically indicated on the Drawings.
- G. Electrical Nonmetallic Tubing:
1. Where specifically indicated on the Drawings.
- H. Non-metallic:
1. Non-metallic raceway shall be used only where specifically indicated to be used in the Contract Documents.
  2. Non-metallic raceway shall only be used where specifically approved for use by the Designer.

- I. Conduit Sleeves:
  - 1. In accessible but concealed ceiling cavities, wherever a cable needs to pass through a wall, floor, ceiling, bulkhead (or similar building obstruction) to get from one space to another.
  - 2. In unfinished areas, high to the ceiling, where a cable not installed in raceway, needs to pass through a wall, floor, ceiling, bulkhead (or similar building obstruction) to get from one space to another.
  - 3. Wherever one or more conduits must pass through a poured-in-place formed concrete structure.
- J. Wireway:
  - 1. Where specifically indicated on the Drawings.
- K. Communications Poles:
  - 1. Where specifically indicated on the Drawings.

### **3.5 DISCRETE CABLE SUPPORT USAGE**

- A. Discrete cable supports shall be used to support cable that is not installed within raceway, cable tray or ladder rack.
- B. Discrete cable supports shall be supported from the building structure, in a manner that is code compliant.
- C. Discrete cable supports shall be anchored using accessories and hardware that is manufactured or recommended by the support manufacturer.
- D. Discrete cable supports shall be spaced at horizontal increments not exceeding 60 inches on center. Additional supports shall be installed to limit cable sag to less than 9 vertical inches.

### **3.6 BOX USAGE**

- A. Boxes:
  - 1. Boxes shall be used at device and equipment locations. Raceway shall terminate into an approved box, except where indicated.
  - 2. Standard wall and ceiling boxes shall be used in walls and ceilings except where specialty boxes are indicated.
  - 3. Boxes designed expressly for use within floors shall be used within floors. The type of box used shall be appropriate for the floor construction.
  - 4. The size and type of boxes used shall accommodate the quantity and type of cable, raceway and devices the box must accommodate.
  - 5. Junction boxes and pull boxes shall be sized to comply with the NEC, but not less than the sizes indicated in the Contract Documents.
  - 6. Custom size and special order boxes shall be provided where custom sizes and special order boxes are required to meet the project requirements.

**3.7 INSTALLATION**

- A. General:
  - 1. Install in accordance with local codes. Adhere to clearance and fire protection regulations.
  - 2. Install above-grade pathways parallel to and perpendicular to building elements.
  - 3. Install pathways plumb and level except where changes in elevation are specifically necessary for constructability.
  - 4. Document the exact routing of concealed pathways on as-built drawings.
- B. Bonding and Grounding:
  - 1. Conductive components of the pathway systems shall be bonded to ground in accordance with the NFPA and the NEC.
  - 2. Additional grounding and bonding shall be provided as set forth in the Contract Documents.
- C. Rustproof Fasteners and Hardware:
  - 1. Install pathway components and associated mounted devices with stainless steel nuts, bolts, screws and washers when installed on the exterior of the building, when installed within unconditioned building spaces, and when the pathway serves exterior devices or devices in areas prone to sustained humidity levels in excess of 60-percent.
- D. Conduit:
  - 1. Install conduit in a concealed manner except where approved by the Designer in advance.
  - 2. Install conduit terminations into boxes and enclosures using fittings featuring locknuts and insulating throat liners.
  - 3. Install insulating bushings on the exposed ends of conduit stubs and sleeves.
  - 4. Install insulating bushings on the exposed threaded portion of conduits and conduit fittings that terminate conduit to a box or equipment enclosure.
  - 5. Support conduits by using pipe straps or trapeze hangers. Space supports not more than 8 feet on center. Secure supports by means of toggle bolts, inserts or expansion bolts.
  - 6. Space wall brackets supporting conduits not more than 4 feet 6 inches on center. Secure supports by means of toggle bolts, inserts or expansion bolts.
  - 7. Support raceway components directly from structural building systems, not from ceiling suspensions systems. Provide supplemental supports for junction or pull boxes.
  - 8. Conceal conduit raceways under floors, in walls, above ceilings and in furred spaces within finished building areas.
  - 9. Support single conduits 1-1/2 inches and larger by means of rod and cast ring hangers. Support multiple runs in similar manner or use a common trapeze hanger system.
  - 10. Provide two-hole sheet metal pipe straps for surface mounted conduit supports on walls up to a height of 8 feet above the finished floor.
  - 11. Pinch type hangers similar to minerallac shall only be used at heights greater than 8 feet.
  - 12. Protect conduits during construction with temporary plugs or caps. Securely cap conduits until pull string, or cable is installed.
  - 13. Do not install conduit horizontally in concrete slabs on grade.
  - 14. Provide expansion/deflection fittings where raceway crosses the building expansion joints.
    - a. Utilize manufacturer recommendations for installation
    - b. Provide external bonding jumpers to bond metallic conduits across joint.
  - 15. Conduit Routing:
    - a. If specific routing information appears on the Drawings, route and maintain conduits as shown. Should interference or a conflict arise, consult the Designer before proceeding with the Work.

- b. If specific routing information does not appear on the Drawings, Determine the best route for the conduit in accordance with code, accessibility and other project guidelines.
  - 16. Conduit bends:
    - a. Bends shall be made so that the conduit will not be flattened or kinked and so that the internal diameter of the conduit is not reduced.
    - b. The radius of the curve of the inner edge of any bend shall not be less than indicated by the National Electrical Code and TIA/EIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.
    - c. All conduit bends or fabricated elbows shall have a bend radius equal or greater than 4 times the trade size.
    - d. When it is necessary to make field bends, use tools manufactured for conduit bending.
      - 1) Heating of metallic conduit to facilitate bending is not permitted.
    - e. Constructing an outside entrance to a building from buried conduit to penetrate above the ceiling line will allow an exception for a 4 inches LB fitting at one end to allow placement of the conduit flat to the building outside wall.
  - 17. Do not cut, burn, or drill any structural member to pass through or mount any pathway product without first obtaining approval in writing from the building architect and structural engineer.
  - 18. Install above-ceiling conduits a minimum of 7 inches above ceiling tiles to permit ceiling tile removal.
  - 19. Install conduits at least 6 inches away from insulated pipes, steam lines or any other hot pipes which they pass. Where the lines are not insulated, the clearances shall be increased until the temperature of the conduit, with no live conductors enclosed, does not rise above the ambient temperature of the installation area.
  - 20. Install flashing and counter flashing or pitch pockets for waterproofing of raceways, outlets and fittings that must penetrate the roof.
  - 21. Install oversized sleeves in forms for new concrete walls, floor slabs, and partitions to allow for the passage of raceways.
  - 22. Waterproof sleeved raceways shall be provided below grade and in areas prone to high moisture and condensation.
  - 23. Outside Plant Conduits
    - a. All conduits shall drain into open bottom hand holes.
    - b. Minimum depth is 24-30"
    - c. Conduits may slope from middle of run
- E. Pull Boxes:
- 1. Install each pull box indicated on the Drawings.
    - a. As additionally required by Code.
  - 2. Install additional pull boxes outside the building envelope:
    - a. Every 500 running feet of below-grade raceway.
    - b. Every 180 degrees of raceway bend.
    - c. Every 100 feet of above-grade raceway. (less than 2")
    - d. Every 200 feet of above-grade raceway (2" and larger)
    - e. As additionally required by Code.
  - 3. Install pull boxes in areas that will be accessible after installation. Accessible areas include spaces above removable tile ceilings and behind access doors that are installed expressly for this purpose. Do not install pull-boxes in locations that will not be accessible after construction is complete and is not accessible after permanently installed furniture or fixtures are installed.
  - 4. Size boxes in accordance with the NEC. Use larger boxes where so specified.
  - 5. Support boxes rigidly.



6. Land conduits on the boxes such that conduits enter and exit across from each other on opposite sides of the box so as to facilitate straight line pulling of cable through the box.
  7. Do not use pull boxes in lieu of conduit bends, except as necessary by design or to meet constructability constraints.
  8. When directional transition of the cables is necessary through a box, land conduits on the box so that they permit the largest possible bending radius for those cables that will pass through the box.
- F. Pull Stings:
1. Install a usable pull string in every pathway prior to the installation of cables. The string shall be installed after pathway installation and prior to such time as the cable installer desires to install cable within the pathway. The string shall be used as an aid to the installation of cables.
  2. Install a replacement pull string in each pathway as part of the cable installation process to facilitate installation of additional cable(s). Tie the pull-string off and tag for "Future Use."
- G. Innerduct:
1. Install innerduct within and along pathways that will be used to accommodate fiber optic cables.
    - a. Plenum rated innerduct shall be used in pathways that are not 100-percent conduit.
    - b. Exception: Innerduct is not required in those pathways that will contain exclusively armored-type fiber optic cables.
- H. Spillways:
1. Install cable spillways where cable(s) will exit a conduit sleeve, cable tray, or wireway and where they would otherwise be unsupported for more than 6 inches.
- I. Telecommunication Poles:
1. Mount straight and anchor to building structure above the ceiling line.
  2. Provide mounting hardware, entrance end fitting, and ceiling trim plate.
  3. Utilize cutouts or add-on compartments for jack frames.
  4. Isolated pathway from electrical circuits with separate internal raceway.
- J. Discrete Cable Supports:
1. Install supports in areas that will be readily accessible after installation (e.g., above accessible suspended ceilings; up within the building structure in unfinished areas).
  2. Do not install supports in any location that is not readily accessible and cannot be reached by the hand of an individual standing flat footed on the ground, a ladder or scaffolding. Do not install in areas where an individual has to strain to reach or where a pole will be required to access.
  3. Install separate discrete cable support pathways for cables from each system. Where the allowed capacity of an individual support will be exceeded, install multiple parallel pathways.
  4. Install separate discrete cable support pathways for cables from the same system that carry signals that could negatively interfere with one another. Array supports vertically using an appropriate spacing not less than 6 inches for every 6 dB of nominal voltage differential between the cables.
  5. Attach supports directly to vertical building surfaces, or from overhead structural members using threaded rod and other approved attachment methods. Support of cables by use of suspended ceiling wires shall not be permitted.
  6. Install supports plumb and square.

7. Install horizontal runs of cables supports level. Change elevation only where necessary for coordination with other trades and pathways of other systems.
8. Mount the bottom of supports approximately 12 inches above the top of suspended ceilings.
9. Install cable supports at intervals not exceeding 5 cable feet.
10. Install supports so that they will not interfere with the removal or installation of ceiling tiles.
11. Provide support in close proximity of device conduit pathway termination for service loop.

**K. Device Boxes:**

1. New-work and old-work device boxes shall be installed flush with or slightly recessed below the finished surface. Do not recess boxes more than is permitted by code, nor more than .078 inches (2mm). Old-work boxes require advanced craftsmanship and construction techniques to achieve specification compliance for communications Work.
2. The installed elevation of boxes shall generally be as indicated on the drawings. Elevations shall be adjusted in the field to ensure a clean appearance resulting from coordination of the new box elevations to match the existing box elevations. Where the specified box elevations and existing condition box elevations differ by more than 4 inches, seek the direction of the Designer prior to installation.
3. Device boxes and associated cover plates shall not span different types of wall finishes either vertically or horizontally. Horizontal and vertical position of boxes shall be adjusted at time of installation to ensure that this condition does not exist after finish is completed.
4. Boxes in masonry shall be installed so that the specified over plates will cover the mortar joints and cut openings completely.
5. Device boxes shall be installed so that they are securely and rigidly attached to structure. Gypsum board and similar non-structural board shall not be used for box support.
6. Devices boxes shall not rely on raceway as a means of support. Boxes shall be fully supported by surrounding building structure.
  - a. Provide sufficient support for ceiling device boxes to support weight of installed products.
  - b. Provide tile support bridge for device box in accessible ceiling.
7. Device boxes shall be installed plumb and level to within the following limits:
  - a. Maximum one-tenth (1/10) of one degree from plumb and from level, and;
  - b. Maximum difference from level of .078 inch (2mm) at one end of the box relative to the other end of the box, and;
  - c. Maximum difference from plumb of .078 inch (2mm) at the top of the box relative to the bottom of the box.
8. Boxes shall be shimmed as necessary to insure level and plumb installation.
9. Install gaskets on boxes installed outside and in wet or damp locations (e.g., tunnels, crawlspaces, pits).
10. Device boxes shall be protected from plaster, drywall mud, mortar, and other construction debris.
11. Floor boxes shall be installed flush and true with the finished floor, or otherwise in accordance with the manufacturer's instructions.
12. Boxes shall be cleaned of debris after installation.
13. Boxes shall be cleaned of debris thoroughly prior to installation of cover plates;
14. Install blank cover plates on each unused device box.
15. Knock out requirements exceeding manufacturers standard sizes shall be accommodated with punch of correct size.

**L. Sleeves and Penetrations:**

1. Sleeves through poured-in-place concrete surfaces shall be set in place prior to the concrete pour and protected from concrete ingress.

2. Sleeves through floors shall be installed to prevent the passage of water between the sleeve and the floor.
3. Install cable-protecting insulating bushings on the each end of each sleeve.
4. Extend through-the-wall sleeves a minimum of 2 inches beyond the wall surface. Extend the sleeve a greater distance where necessary to permit proper installation of cable-protecting bushings and any associated cable waterfalls.
5. Extend through-the-floor sleeves to a consistent elevation of 4 inches to 6 inches above finished floors, except where otherwise noted on the Drawings.
6. Fill the voids between sleeve and building surface with approved fire stop material sufficient to maintain the fire-rating of the building surface.
7. Firestop or plug all penetrations, conduits and sleeves to prevent the movement of air between spaces.

**M. Conduit Stubs:**

1. Install cable-protecting insulating bushings on each conduit stub.

**N. Supports:**

1. Fabricated Support Devices:
  - a. Conform to the manufacturer's recommendations for selection and installation of supports.
  - b. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
  - c. Support parallel runs of horizontal raceways together on trapeze-type hangers.
  - d. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners shall be used in lieu of hangers for 1-1/2 inches and smaller raceways above suspended ceilings only.
  - e. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
  - f. Support exposed and concealed raceway within 1 foot of box and access fittings. In horizontal runs, support at the box and access fittings shall be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
  - g. In vertical runs, arrange supports so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on the ends of the raceway.
2. Miscellaneous supports:
  - a. Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, pull boxes, junction boxes, and other devices.
  - b. Support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.
3. Fastening:
  - a. Fasten pathway products and its supporting hardware securely to the building structure in accordance with the following:
    - 1) Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided

with lock washers and nuts shall be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

- 2) When installing fasteners in concrete or CMU structures, do not cut reinforcing bars.
  - 3) Ensure that the load applied to any fasteners does not exceed 25-percent of the proof test load. Use vibration-and shock-resistant fasteners for attachments to concrete slabs.
  - b. Raceway supports: Hanger spacing shall be as required for adequate support of the raceway, but in no case shall there be less than one hanger per 5 feet of raceway length.
- O. Pathway Evacuation:
1. Prior to the installation of cable:
    - a. Clean and vacuum boxes, raceway, cable tray, and discrete cable supports.
    - b. Remove solids or other hindrances that could impede its full utilization or that could damage cable during or after installation.
    - c. Remove liquids. Blow out until raceway is dry, sufficiently that the installed cables will not be subjected to contact with them.
  2. Where existing raceways are reused, remove liquid from the raceway.
- P. Water Proofing:
1. Protect raceways from moisture infiltration in areas where moisture penetration is probable (e.g., outdoors, natatoriums, wash bays).
  2. Provide watertight fittings where one or more cables exit the pathway in areas where moisture penetration is probable.
  3. Seal below-grade conduit joints to prevent moisture infiltration.
  4. Seal joints of conduits in high-moisture areas to prevent moisture infiltration.
  5. Pressure or vacuum test below-grade conduits before and after concealing the conduits to ensure resistance to moisture ingress.
- Q. Repair and Patching:
1. Holes and other penetrations into building surfaces or structure that are created to facilitate pathway installation but that are not ultimately used shall be filled, repaired, and restored to their original strength, appearance and integrity.
  2. Damage to building or property that occurs during the course of pathway installation shall be repaired and restored to its original condition prior to damage.
- R. Cover Plates
1. Provide cover plates over the openings of junction boxes, pull boxes and cast boxes.

**END OF SECTION 27 0528**

**SECTION 27 0550****FIRESTOPPING FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials (BOM).
  - 2. Product Datasheets.
  - 3. Material Safety Data Sheets (MSDS).
- B. Closeout Submittal:
  - 1. Product Datasheets.
  - 2. Material Safety Data Sheets (MSDS).
  - 3. Schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Firestop: A fire-rated material, device, or assembly of parts installed in a penetration of a fire-rated barrier.
  - 2. Firestop system: A specific construction consisting of the material(s) (firestop penetration seals) that fill the opening in the wall or floor assembly and any items that penetrate the wall or floor, such as cables, cable tray, conduit, ducts, pipes, and any termination devices, such as electrical outlet boxes, along with their means of support.
  - 3. Firestopping: The process of installing listed, fire-rated materials into penetrations in fire-rated barriers to reestablish the fire-resistance rating of the barrier.
  - 4. Intumescent firestop: A firestopping material that expands under the influence of heat.
- B. Reference Standards:
  - 1. ASTM E 84, "Surface Burning Characteristics of Building Materials."
  - 2. ASTM E 119, "Fire Tests of Building Construction and Materials."
  - 3. ASTM E 814, "Fire Tests of Penetration Firestop Systems."
  - 4. ANSI/UL 263, "Fire Tests of Building Construction and Materials."
  - 5. ANSI/UL 723, "Surface Burning Characteristics of Building Materials."
  - 6. ANSI/UL 1479, "Fire Tests of Through Penetration Firestops."
  - 7. Underwriters Laboratories Inc. (UL) – Fire Resistance Directory.
  - 8. National Fire Protection Association (NFPA) – NFPA 70: National Electrical Code.
  - 9. National Fire Protection Association (NFPA) – NFPA 101: Life Safety Code.
  - 10. TIA-569-B, Annex A, "Firestopping."
  - 11. The most current published edition of the "Telecommunications Distribution Methods Manual (TDMM)" published by the Building Industry Consulting Services International (BICSI), "Firestopping."

### **1.3 QUALITY ASSURANCE**

- A. Where the local jurisdiction requires additional training, licensing, permits and certifications to perform firestopping, the entity and individuals performing the work shall comply with such requirements.

### **1.4 SYSTEM DESCRIPTION**

- A. All penetrations through floors, ceilings, and walls shall be sleeved. All sleeves through floors and walls shall be firestopped.
1. The firestopping system shall resist and limit the spread of fire, heat, smoke and gasses through otherwise unprotected openings in rated assemblies, including walls, partitions, floors, ceilings/roof and similar locations, restoring the integrity of the fire rated construction to its original fire rating, in accordance with applicable codes, standards, and as directed by the AHJ.
  2. All sleeves into spaces containing pressurized fire suppression systems shall be self-sealing sleeve assemblies.
- B. Firestopping requirements and locations are not specifically indicated on the Drawings. Review the architectural and other related Drawings to determine fire- and smoke-rated walls and floors, including minimum rating requirements. Provide firestopping Work associated with Division 27 and Division 28 (where applicable) per the requirements of the Contract Documents.
1. At a minimum, firestopping shall equal or exceed the rating of the wall or floor and with a minimum UL classification for 1-hour fire and cold side temperature ratings.
  2. Firestopping systems shall be listed for the specific combination of fire-rated construction, type of penetrating item, annular space requirements, and fire rating, including the following criteria:
    - a. F-Rating: Where applicable, provide products that meet the intent of the F-rating classification for passage of flame per ANSI/UL 1479 or ASTM E814 for through penetrations. Rating shall be equal to or greater than the fire-resistance rating of the assembly in which the firestopping will be installed.
    - b. T-Rating: Where applicable, provide products that meet the intent of the T-rating classification for the transfer of temperature per ANSI/UL 1479 or ASTM E814 for through penetrations. In habitable areas where penetrating items are exposed to potential contact with materials on fire side(s) of rated assembly, T-rating must equal F-rating
    - c. L-Rating: Provide products that meet the intent of the L-rating classification for the movement of smoke per ANSI/UL 1479 or ASTM E814 for through penetrations.
    - d. W-Rating: Where applicable, provide products that meet the intent of the W-rating classification for passage of water per ANSI/UL 1479 or ASTM E814 for through penetrations. Shall meet UL Water Leakage Test, W-Rating – Class 1 requirements for systems tested and listed in accordance with ANSI/UL 1479 or ASTM E814.
    - e. Wall Penetrations: Through penetration systems shall be symmetrical, with the same rating from both sides of the wall.
  3. Firestopping shall be installed within the interior cavity of conduit sleeves, raceway, cable tray and other cable conveyances where the interior volume of the conveyance is open and exposed in one space while the opposite end of the conveyance is open and exposed within another.
  4. Firestopping shall be installed where preparations for, or installation of equipment (e.g., cabling, devices) cause the fire or smoke rating of a building component or assembly to be reduced as a result of some action taken.



5. Fire-resistive joint sealants: Provide joint sealants with fire-resistance ratings as determined per ASTM E 119, but not less than that equaling or exceeding the fire-resistance rating of the construction in which the joint occurs.
6. Firestopping products shall be compatible with each other, with the substrates forming openings, and with the items, if any, penetrating the firestopping, under the conditions represented by the Project, based on testing and field performance demonstrated by the firestopping products/system manufacturer.
7. Firestopping system and products exposed to view, traffic, moisture, and physical contact shall not deteriorate when exposed to these conditions.
8. Firestopping systems for floor penetrations with annular spaces exceeding 4 inches (100 mm) or more in width and exposed to possible loading and traffic shall be capable of supporting the floor loads involved by installing floor plates or by other means.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.

### **2.2 MANUFACTURERS**

- A. To maintain control and integrity of the firestopping applications, utilize a single manufacturer. Specific UL or approved listing agencies systems applicable to each type of firestop condition shall be supplied by a single manufacturer.
- B. Subject to compliance with requirements, provide products by one of the following:
  1. Specified Technologies, Inc. (STI).
  2. 3M Fire Protection Products (3M).
  3. Hilti Corporation (Hilti).
  4. Unique Fire Stop Products.
  5. Nelson Firestop Products.
  6. Unifrax Corporation.

### **2.3 MATERIALS**

- A. Firestopping products shall be tested and Listed for specific fire resistance rated construction conditions and shall conform to construction assembly type, penetrating item type, annular space requirements, and fire rating involved for each separate instance.
- B. Component Types – Utilize as required to meet Project requirements
  1. Intumescent sealants: Single component intumescent latex formulations containing no water soluble intumescent ingredients.
    - a. Basis of Design shall be Specified Technologies Inc. (STI) SpecSeal Series SSS Intumescent Sealant and SpecSeal Series LCI Intumescent Sealant.
  2. Endothermic sealants: Single component latex formulations that upon cure do not re-emulsify during exposure to moisture.



- a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series LC Endothermic Sealant.
  3. Firestop devices: Factory-assembled steel collars lined with intumescent material sized to fit specific outside diameter of penetrating item.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSC Firestop Collars and SpecSeal LCC Firestop Collars.
  4. Wall opening protective materials: Intumescent, non-curing pads or inserts for protection of device boxes to reduce horizontal separation to less than 24 inches (610 mm).
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSP Firestop Putty Pads or SpecSeal Series EP PowerShield Insert Pads.
  5. Firestop putty: Intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers or silicone compounds.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSP Putty.
  6. Intumescent wrap strips: Single component intumescent elastomeric strips faced on both sides.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSW Wrap Strip.
  7. Firestop pillows: Re-enterable, non-curing, mineral fiber core encapsulated with an intumescent coating on all six sides contained in a flame retardant poly bag.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSB Pillows.
  8. Mortar: Portland cement based dry-mix product formulated for mixing with water at Project site to form a non-shrinking, water-resistant, homogenous mortar:
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSM Firestop Mortar.
  9. Silicone sealants: Moisture curing, single component, silicone elastomeric sealant for horizontal surfaces (pourable or non-sag) or vertical surface (non-sag).
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal SIL300 Silicone Firestop Sealant or SpecSeal SIL300 SL Self-Leveling Silicone Firestop Sealant.
  10. Composite sheet: Intumescent material sandwiched between a galvanized steel sheet and steel wire mesh protected with aluminum foil:
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal CS Composite Sheet.
  11. Firestop plugs: Re-enterable, foam rubber plug impregnated with intumescent material for use in blank openings and cable sleeves.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series FP Firestop Plug.
  12. Intumescent collar devices: Steel collar system with intumescent inserts.
    - a. Basis of Design: Specified Technologies Inc. (STI) SpecSeal Series SSC and LCC.
  13. Horizontal wall penetrations in Gypsum Board
    - a. Fire-rated cable grommet: Molded two-piece grommet made from plenum grade polymer with a foam inner core for sealing individual or small, multi-cable bundle penetrations.
      - 1) Basis of Design: Specified Technologies Inc. (STI) Ready Firestop Grommet.
- C. Firestop sleeve assembly kit:
1. Sized to accommodate cable quantities indicated in the Contract Documents plus 20 - percent additional capacity for growth.
  2. Includes steel escutcheon plates and intumescent firestop gaskets sized to fit the specific outside diameter of the sleeve and sandwich the barrier to lock the sleeve in place.
  3. Includes sufficient thickness of intumescent firestop putty to seal the ends of the sleeve to restrict the passage of fire, smoke and superheated gases.
  4. Basis of Design shall be Specified Technologies Inc. (STI) SpecSeal READY SLEEVE and SpecSeal READY SPLIT SLEEVE (for existing cable penetrations).

**D. Accessories:**

1. Provide components for each firestopping system required to install fill materials and to comply with the system performance requirements. Use only components specified by the firestopping manufacturer and approved by the qualified testing and inspecting agency for the designated fire-resistance-rated systems. Firestopping materials shall be asbestos-free and shall not contain flammable solvents. Accessories include but are not limited to the following:
  - a. Permanent forming, damming, backing materials, including the following:
    - 1) Semi-refractory fiber (mineral wool) insulation.
    - 2) Ceramic fiber.
    - 3) Sealants used in combination with other forming/damming materials to prevent leakage of fill materials in liquid state.
    - 4) Fire-rated form-board.
    - 5) Joint fillers for joint sealants.
  - b. Temporary forming materials.
  - c. Substrate primers.
  - d. Collars.
  - e. Steel sleeves.
  - f. Warning labels.

**2.4 COMBUSTIBLES IN PLENUM SPACES**

- A. Passive combustibles installed within plenum spaces that are not UL listed for installation within plenum spaces shall be encased within high-temperature plenum insulation, the purpose of which is to prevent flame propagation and smoke development in the plenum areas. Passive combustibles include such items as non-plenum cables, pipe, low-voltage connector housings.
  1. Plenum insulation shall be UL listed for the application.
  2. Basis of Design: UniFrax FyreWrap 0.5.

**PART 3 - EXECUTION****3.1 GENERAL**

- A. Consult and comply with the AHJ concerning local firestopping requirements.
  1. Where no NRTL tested firestop application exists, manufacturer's engineering judgment derived from similar listed system designs or other tests shall be submitted to the AHJ for review and approval prior to installation.
  2. It is the sole responsibility of the firestopping provider to install tested and approved systems that comply with applicable codes, standards and/or agencies and authorities having jurisdiction.
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with the most current published edition of the "Telecommunications Distribution Methods Manual (TDMM)" published by the Building Industry Consulting Services International (BICSI), including the "Firestopping" article.
- D. Through-penetration firestop systems and construction gap fire resistive systems shall be supplied and installed with approved methods using materials that have been tested and classified to produce a listed and approved assembly.

- E. Provide products that upon curing do not re-emulsify, dissolve, leach, break down or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction.
- F. Openings within floors and walls designed to accommodate cabling shall be provided with re-entenable products that do not cure or dry.
- G. Damaged or expired materials shall be removed from the site and shall not be used in the Work.
- H. Do not use materials that contain flammable solvents.
- I. Sleeves shall be mechanically fastened to the wall, floor, ceiling or roof assembly.

### **3.2 DELIVERY, STORAGE AND HANDLING**

- A. Deliver firestopping products to the Project site in original, unopened containers or packages with intact and legible manufacturer labels identifying product and manufacturer, date of manufacture, lot number, shelf life, if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multi-component materials.
  - 1. Coordinate the delivery date of firestopping materials with the scheduled date of installation to minimize the amount of storage time required at the Project site.
  - 2. Store with a copy of the manufacturer MSDS sheet. Submit a copy of each sheet to the Owner's project manager upon delivery to the site.
- B. Store and handle firestopping materials to prevent deterioration or damage due to moisture, temperature changes, contaminants or other causes. Handle, store and protect products and materials according to the manufacturer's printed recommendations and guidelines.
- C. Do not deliver or install product(s) in conditions that jeopardize the performance of the product.

### **3.3 INSTALLATION**

- A. Install firestopping products in compliance with manufacturer's printed instructions, recommendations and technical information.
- B. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to manufacturer's requirements. Coordinate sizing of sleeves, openings, core drilled holes or cut openings to accommodate through-penetration firestop systems.
- C. Environmental conditions:
  - 1. Install firestopping products when ambient or substrate temperatures are within the requirements recommended by the firestopping manufacturer. Do not install firestopping when ambient or substrate temperatures are outside the limits permitted by the manufacturer or when substrates are wet due to rain, frost, condensation or other causes.
  - 2. Maintain temperatures and environmental conditions within limits recommended or required by manufacturer's printed instructions or technical information for any required periods of time before, during and after installation of materials.

- D. Ventilation: Provide ventilation as required by firestopping manufacturer, including mechanical ventilation if required.
- E. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping. Do not proceed with installation until unsatisfactory conditions have been corrected.
- F. Surfaces shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellants and any other substances that may inhibit optimum adhesion.
- G. Clean openings and joints immediately before installation of firestopping to comply with firestopping manufacturer's printed guidelines and recommendations and the following requirements:
  - 1. Remove foreign materials from surfaces of opening and joint substrates and from penetrating items that could interfere with adhesion of firestopping.
  - 2. Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
  - 3. Remove laitance and form-release agents from concrete.
- H. Provide masking and temporary covering to protect adjacent surfaces and prevent contact with the following:
  - 1. Adjoining surfaces that will remain exposed upon completion of the Work.
  - 2. Surfaces that would otherwise be permanently stained or damaged by such contact or cleaning methods used to remove smears from firestopping materials.
  - 3. Remove masking and temporary covering as soon as possible to do so without disturbing firestopping seal with substrates.
- I. Install fire stop materials, including forming, packing, and other accessory materials, to fill openings around services penetrating floors, walls, ceilings and roofs, to provide fire-resistance ratings indicated for the assembly in which the penetration occurs. Comply with installation requirements established by the manufacturer and testing and inspecting agency.
- J. Install forming/damming materials and other accessories of types required to support fill materials during application and in the position needed to produce the cross-sectional shapes and depths required to achieve fire ratings of designated firestop systems. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
- K. Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:
  - 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.
  - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
- L. Seal between sleeves and pipes and other through-penetration pathway devices with firestop material. Material shall meet applicable fire ratings required.

- M. Firestop systems shall not hamper the performance of fire dampers in ductwork or other safety systems.
- N. Tool non-sag sealants immediately after sealant application and before skinning or curing begins. Form smooth, uniform beads of configuration required to produce fire-resistance rating, as well as to eliminate air pockets, and to ensure contact and adhesion of sealants with sides of joint. Remove excess sealant from surfaces adjacent to the joint. Do not use tooling agents that discolor sealants or adjacent surfaces or that are not approved by the sealant manufacturer.
- O. Firestopping for discrete cable pathways (J-hooks):
  - 1. Discrete cable pathways shall terminate at each barrier and resume on the opposite side such that cables pass independently through fire-rated pathway devices.
- P. Firestopping for cable trays:
  - 1. Openings for cable trays shall be sealed using re-enterable firestopping pillows.

### **3.4 FIELD QUALITY CONTROL**

- A. Components used in firestop systems shall be the same as the products used in fire qualification tests, must be prepared and installed using established quality control procedures, and verified periodically by an independent quality auditor at the manufacturer's facility. The final field installation shall be reviewed and validated by the AHJ.
- B. Do not enclose firestopping with other construction until examinations are completed. Area of Work shall be accessible until inspections are completed by the AHJ.
- C. Where deficiencies are found, repair or replace firestopping at no additional expense to the Owner so that Work complies with requirements.

### **3.5 CLEANING**

- A. Clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling as work progresses.
- B. Remove excess fill materials and sealants adjacent to openings and joints as Work progresses. Use methods and cleaning materials approved by manufacturers of firestopping products and products in which openings and joints occur. Return surfaces to the original condition.
- C. During and after the curing period, protect firestopping from contact with contaminating substances and from damage resulting from construction operations or other causes so that they are without deterioration or damage at time of Substantial Completion.
  - 1. If damage or deterioration occurs, remove damaged or deteriorated firestopping immediately, and install new materials to produce firestopping complying with specified requirements.

**END OF SECTION 27 0550**

**SECTION 27 0553****IDENTIFICATION FOR COMMUNICATIONS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product datasheets.
- B. Labeling schemas.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Labeling of cabling and termination devices.
  - 2. Labeling of equipment.
  - 3. Labeling of Communications Rooms.
- B. Requirements of this Section apply to all Work of this Division and Work Division 28 (where applicable).

**1.3 REFERENCE STANDARDS**

- A. Definitions:
  - 1. Component Identifier / Component ID: See Device ID
  - 2. Device.ID: The unique identifier given to a specific instance of a product, module and assembly. Identifiers are unique within the context of the system and product in which it is used.

**1.4 SYSTEM DESCRIPTION**

- A. The identification system shall be a coordinated system of permanently affixed labels of specified types that are used to uniquely identify each instance of a product and the space in which it is located. The following items shall be identified:
  - 1. Cables.
    - a. All cables shall have cable ID on the jacket at each end 4-6 inches from termination.
  - 2. Telecommunications cabling cross-connect Blocks, including 66-blocks and 110-blocks.
  - 3. Patch Panels.
  - 4. Faceplates.
  - 5. Individual connection jacks, receptacles and terminals.
  - 6. Remote Equipment enclosures/cabinets not within telecommunications rooms.
  - 7. Equipment racks and cabinets within telecommunications rooms.
  - 8. Telecommunications Backboards.
  - 9. Rooms containing communications or security products.
  - 10. Device boxes, junction boxes, pull boxes, floor boxes, wall boxes, ceiling boxes and other forms of boxes used for passage, splicing, or termination of cables.

11. Equipment power cord plugs.

B. The labeling schema used for horizontal and backbone structured cabling systems shall be TIA/EIA-606-A, or most current version, compliant.

C. Label Type Schedule

LABEL TYPE SCHEDULE		
APPLICATION	TYPE	NOTES
EQUIPMENT RACK - FRONT	DB	
EQUIPMENT RACK - REAR	DB	
PATCH PANELS – BACKBONE CABLES	CB	
PATCH PANELS – HORIZONTAL CABLES	CB	
FACEPLATES – HORIZONTAL	CB	CLEAR BACK
FACEPLATES - CUSTOM	DE	ENGRAVED; SCREENED
FACEPLATES – MULTISERVICE	CB	CLEAR BACK; ENGRAVED
OUTLETS – HORIZONTAL	CB	
OUTLETS – CUSTOM FACEPLATE	DB	
CABLES - HORIZONTAL	CA	
CABLES - BACKBONE	CA	
AV CABLES	CA	
COMMUNICATIONS BACKBOARDS	DC	
CONNECTING BLOCKS	PI	WITH PLASTIC COVER
FIBER OPTIC PANEL	PI	
ABBREVIATED DEFINITIONS CA=SELF LAMINATING WRAP-AROUND), CB=SELF LAMINATING DA = LAMACOID, DB=TAPE TYPE, DC=IMPRINTED/ETCHED; DE=ENGRAVED PI=PRINTED INTEGRAL LABEL; RA=LAMACOID SEE SECTION 270553 FOR SPECIFICATIONS OF VARIOUS LABEL TYPES		

## PART 2 - PRODUCTS

### 2.1 GENERAL

A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.



**2.2 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Brady
  2. Brother
  3. Casio
  4. Hubbell
  5. Panduit
  6. Hellerman/Tyton
  7. Thomas and Betts

**2.3 PERFORMANCE**

- A. Labels shall be designed to remain permanently affixed under typical environmental conditions for the life of the product identified.
- B. Nomenclature shall be permanent and non-fading under typical environmental conditions.
- C. Adhesive labels shall remain attached to the affixed product in continuous conditions of 90% relative humidity and temperatures of 100-degrees Fahrenheit (38-degrees Celsius).

**2.4 CABLE INFRASTRUCTURE LABELS**

- A. Type CA:
1. Self-laminating type.
  2. Adhesive backed.
  3. Opaque solid-color background area, color for nomenclature: White.
  4. Clear self-laminating wrap-around cover for protection of nomenclature.
  5. Available in a variety of heights and widths to suit the cable being labeled.
  6. Printing area of the label available in a wide variety of sizes to accommodate the specific nomenclature to be applied.
  7. Overall label width: Minimum 1 inch (25 mm); Maximum 2 inches (50 mm).
  8. Opaque printing area length: Minimum 1/2 inch (12 mm); Maximum 1-1/4 times the cable circumference.
  9. Self-laminating wrap length: 1-1/2 to 2-1/2 times the cable circumference.
  10. Bold computer-generated and commercial printer applied high-contrast project and system specific nomenclature.
- B. Type CB – Tape Type:
1. Self-laminating type.
  2. Adhesive backed.
  3. Opaque solid-color background area, color for nomenclature: White.
  4. Available in a variety of heights and widths to suit the termination being labeled.
  5. Printing area of the label available in a wide variety of sizes to accommodate the specific nomenclature to be applied.
  6. Overall label width: Minimum 1 inch (25 mm); Maximum 2 inches (50 mm).
  7. Opaque printing area length: Minimum 1/2 inch (12 mm); Maximum 1-1/4 times the cable circumference.

8. Bold computer-generated and commercial printer applied high-contrast project and system specific nomenclature.

C. Type PI – Tape Type:

1. Integral card type.
2. Opaque solid-color background area, color for nomenclature: White.
3. Heights and widths to suit the termination being labeled.
4. Printing area of the label to accommodate the specific nomenclature to be applied.
5. Bold computer-generated and commercial printer applied high-contrast project and system specific nomenclature.
6. Provide with clear plastic covers to protect label.

## **2.5 DEVICE LABELS**

A. Type DA – Lamacoid 2-Ply:

1. Lamacoid type 2-ply plastic material.
2. Self-adhesive backing for adhesion to labeled item.
3. Available in a wide variety of sizes to suite the application.
4. Available with a wide-variety of background colors.
5. Available with a variety of different nomenclature colors.

B. Type DB – Tape Type:

1. Tape-type construction.
2. Material: Polyester.
3. Working temperature range: -40 to 248 degrees Fahrenheit (-40 to 120 degrees Celsius)
4. Opaque solid-color background over which nomenclature is applied.
5. Self-adhesive backing for adhesion to labeled item.
6. Designed for thermal-transfer based machine imprinting of nomenclature.
7. Available in a wide-variety of manufacturer sizes.
8. Available with a wide-variety of background colors.
9. Available with a variety of different nomenclature colors.

## **2.6 CABLE LABEL HEATSHRINK**

- A. Should any condition arise in which cable labels are used that are neither self-laminating nor permanent, then properly sized clear heat-shrink shall be applied over the label to make it permanent.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

A. General:

1. Label each instance of each product.
2. Label each connector of each product.
3. Install labels so that they are legible after installation.
4. Install labels so they are parallel to the dominant visual lines of the product identified.
5. Install labels of the appropriate size for the application.
6. Maintain consistency in label sizes that are used for labeling similar applications.

7. Install secondary labels on the rear of products that are mounted within racks, within equipment enclosures/cabinets, within furniture or casework, and in any application where the rear of the product is accessed for termination, installation, service, operation or adjustment.
8. Coordinate "final" room numbers or identifiers with the Owner prior to performing work; all labeling shall perform to operational room identifiers. If actual room numbers differ from architectural room numbers both shall be included on the as-built floorplans.
9. Campus environments with multiple buildings shall add a building identifier to the labeling in each building.

**B. Cables:**

1. General:
  - a. Uniquely identify each cable so that no two cables serving a single system utilize the same identifier.
  - b. Cables that terminate within different architectural spaces shall include both the source and destination space identifiers on the label in addition to a unique cable identifier
  - c. Install a primary label near the end of cable.
  - d. Install a secondary label (with identical nomenclature as the primary label) near the ends of the cable at such point that the label is viewable and readable when the cable is in its final dressed position.
  - e. Utilize specified labeling schemas. Substitute schema may be considered if submitted to, reviewed and returned by the Designer without exceptions.
2. Horizontal Cables:
  - a. Label in accordance with TIA/EIA-606-A, or most current version.
  - b. Horizontal labeling schema:
    - 1) "Communication Room Identifier"—"Outlet Room Number"—"Rack, Patch Panel and Patch Panel Port Number."
3. Backbone Cables:
  - a. Label in accordance with TIA/EIA-606-A, or most current version.
  - b. In addition to labels at each end, apply a label at each junction/pull point to identify the cable.
  - c. Cabling labeling schema:
    - 1) Service designation and number: CB = Copper Backbone, FB = Fiber Backbone, VB = Video Backbone (e.g., CB.01, FB.01, FB.02, VB.01)
    - 2) Interconnected Communication Room designations (e.g., ER01—TR04)
    - 3) Composite Examples:
      - a) Example: CB.01—ER01—TR02.
      - b) Example: CB.01—ER01—TR03.
  - d.
4. Patch Cables:
  - a. Label with the same unique identifier at each end.
5. Multi-Cable Assemblies and Tethers:
  - a. Label the overall assembly, sleeve, or jacket (as applicable) at both ends.
  - b. Label each individual cable member at both ends.
  - c. If the cable assembly features connectors on the end of any cable member, affix labels also on the connector. Use user-friendly nomenclature that identifies the use of the connector and the port to which it mates.
  - d. See illustrations at the end of this Section.

**C. Faceplates and Outlets:**

1. Faceplates – General:
  - a. Label each faceplate with a Device.ID label.

- 1) Exception: Faceplates used exclusively for Horizontal cables do not need to feature a Device.ID label.
  - 2) Exception: Blank faceplates are not required to have a Device.ID label, except where noted.
  - b. Use labels with a clear background or a background color that matches the plate. On custom fabricated faceplates, label shall be integral to the plate by means of engraving or screening or other approved means.
  - c. See illustrations at the end of this Section.
  2. Faceplates – with Horizontal Cables:
    - a. Label modular outlet frame(s) with a label identifying origination and destination rooms of the horizontal cable(s) present at the faceplate. When non-modular faceplates are used, affix the label to the plate.
  3. Outlets/Connectors – General:
    - a. Label each outlet.
  4. Outlets/Connectors – Horizontal Cables:
    - a. Identify the specific patch panel and port to which the opposite end of the cable is connected.
  5. Use .35" tape with 9 pt Arial font.
- D. Cross-Connect Blocks:
1. 110-Style:
    - a. Label the front of the block directly above or below (as indicated by the manufacturer) each position in the block.
    - b. Label connections in numerical order and corresponding to the faceplate outlet schema (horizontal cabling) or the opposite end labeling schema (backbone cabling), dependent upon use.
    - c. Label the upper left corner of each block designating the service of that particular block.
  2. 66-Style:
    - a. Label the front of the block directly above or below (as indicated by the manufacturer) each position in the block.
    - b. Label connections in numerical order and corresponding to the faceplate outlet schema (horizontal cabling) or the opposite end labeling schema (backbone cabling), dependent upon use.
    - c. Label the upper left corner of each block designating the service of that particular block.
- E. Patch Panel:
1. Chassis – General:
    - a. Label each panel chassis with a Device.ID.
    - b. Affix chassis labels aligned with the left or right edge of the product. Locate consistently across chassis in the rack and throughout the project.
  2. Chassis – for Horizontal Cabling:
    - a. In lieu of or in addition to the Device.ID uniquely label the chassis for each panel within each Communication Room in accordance with the following schema:
      - 1) "Letter" or "Letter Letter" where letters A-Z or dual letter assemblies AA-ZZ are valid.
  3. Individual Connectors – for Horizontal Cabling:
    - a. Label each connector on each panel in order from Left to Right and Top to Bottom 1 to "X," where "X" is the number of connector spaces on the panel.
    - b. In addition, the connector label nomenclature shall clearly identify the room number in which the opposite end of the cable is terminated.
  4. Individual Connectors – Others:

- a. Label each connector.
  - b. Use color-coded nomenclature acceptable to the Designer.
- F. Patch Bays (e.g., Audio, Video):
  1. Label each patch bay with a Device.ID.
  2. Label each connector on the patch bay.
  3. Use color-coded nomenclature acceptable to the Designer.
  4. Where the patch bay features an integral labeling strip, label the connectors using the strip following the techniques recommended by the manufacturer.
  5. Where the Drawings depict additional means of labeling, provide additional labels with designer reviewed nomenclature.
- G. Equipment Racks:
  1. Label each equipment rack with a unique identifier.
  2. Accurately record the nomenclature on the project as-built documentation.
  3. Affix a primary label to the front of the rack.
  4. Affix a secondary label to the rear of the rack.
  5. Locate labels on the upper-most part of the rack, typically the frame, in an area that is clearly visible if doors are installed and closed.
  6. Label each equipment rack to match the designation indicated on the floor plans
  7. Labels shall be black text on white background.

### **3.2 LABEL PROTECTION**

- A. Cable Labels: If at any time during the course of the project a condition arises for which cable labels are used that are neither self-laminating nor permanent, then such labels shall be protected with properly sized clear heat-shrink to protect the label and to make it permanent.

### **3.3 RECORD DRAWINGS**

- A. Accurately record the labels used for identifying items within the project as-built documentation.

**END OF SECTION 27 0553**

**SECTION 27 0810****VERIFICATION TESTING OF STRUCTURED CABLING****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials (BOM):
    - a. Make, Model, Serial Number.
    - b. Description of the test instrument.
    - c. Tests for which the instrument will be used.
  - 2. Product Datasheets: For each test instrument to be used.
  - 3. Product Calibration Certificate for each test instrument: Certificate shall document the date of calibration and the name of the calibration organization.
- B. Closeout Submittal:
  - 1. UTP Cable Test Result Documentation:
    - a. Make, model, serial number and date of last calibration of each piece of test equipment used.
    - b. Summary Test Reports: Paper copy of the summary test results shall be provided that lists the links that have been tested with the summary information as set forth in Part 3.
    - c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested link must contain the information as set forth in Part 3.
      - 1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.
  - 2. Fiber Optic Test Result Documentation:
    - a. Make, model, serial number and date of last calibration of each piece of test equipment used.
    - b. Summary Test Reports: Paper copy of the summary test results shall be provided that lists the links that have been tested with the test summary information as set forth in Part 3.
      - 1) Fiber tests from the same cable between the same 2 points shall not vary over .25db from each other.
    - c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested fiber link must contain the information as set forth in Part 3.
      - 1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.
  - 3. Coaxial Cabling Test Result Documentation:
    - a. Make, model, serial number and date of last calibration of each piece of test equipment used.
    - b. Summary Test Reports: Paper copy of the summary test results shall be provided that list links that have been tested with the summary information as set forth in Part 3.
    - c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested link must contain the information as set forth in Part 3.

- 1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.

## **1.2 REFERENCES**

### **A. Definitions:**

1. IDC: Insulation displacement connector.
2. Margin: Designates the difference between the measured value and the corresponding test limit value. For passing links, 'worst case margin' identifies the smallest margin over the entire frequency range; the point at which the measured performance is "closest" to the test limit.
3. NVP: Nominal Velocity of Propagation expresses the speed of the electrical signals along the cabling link in relation to the speed of light in a vacuum. Insulation characteristics and twist rate of the wire pair influence NVP in minor ways. Typically, an 'average' value for NVP is published for four wire-pairs in a cable.
4. OLTS: Optical loss test set.
5. OTDR: Optical time domain reflectometer.

### **B. Reference Standards:**

1. ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard.
3. ANSI/TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
4. ANSI/TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
5. ANSI Z136.2, ANSI For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources.
6. ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements.
7. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.
8. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR.
9. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.
10. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant.
11. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
12. TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems.
13. The most current published edition of the "TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL" published by the Building Industry Consulting Services International (BICSI).

## **1.3 COORDINATION**

- A. The Owner or the Owner's representative shall be invited to witness and review field testing and procedures. The representative shall be notified of the start date of the testing phase a minimum of five (5) business days before testing commences.



**1.4 QUALITY ASSURANCE**

- A. Testing shall be supervised by an individual certified by BICSI as an RCDD.
- B. Individuals performing tests shall have attended and have successfully completed an appropriate training program and have obtained a certificate as proof thereof. Appropriate training programs include but are not limited to installation certification programs furnished by BICSI or the ACP (Association of Cabling Professionals).
- C. Test equipment shall perform in accordance with the manufacturer's published specifications and shall have been calibrated by either the manufacturer or a recognized independent test equipment calibration organization within the 365 day period prior to its use.

**1.5 SYSTEM DESCRIPTION**

- A. 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.
- B. Perform testing on each cabling link (connector to connector), including copper twisted pair, fiber optic (multi-mode and single-mode) and coaxial cabling.
  - 1. Fiber optic Intra-Building Links shall be tested as Tier 1.
  - 2. All fiber optic links including more than one segment shall be tested as Tier 2 whether involving fusion splicing or mechanical connection.
- C. Testing shall not include any active devices or passive devices within the link other than cable, connectors, and splices.
  - 1. Link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
- D. In addition to the tests identified in this document, contractor shall notify the Owner or Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. These tests shall be implemented with additional measurement results recorded at no additional costs.

**PART 2 - PRODUCTS****2.1 TEST EQUIPMENT REQUIREMENTS**

- A. Subject to compliance with requirements, available test equipment manufacturers that may be used for testing include, but are not limited to the following:
  - 1. Fluke Corporation.
  - 2. Ideal
  - 3. Softing
  - 4. Viavi
- B. UTP Cable Test Equipment:

1. Category 5e, 6 and 6A (Augmented Category 6) Compliance: Coordinate with the Drawings and related Sections for project requirements.
  - a. The test equipment (tester) shall comply with the accuracy requirements for field testers as defined in ANSI/TIA-1152. The tester, including the appropriate interface adapter, must meet the specified accuracy requirements. The accuracy requirements for the permanent link test configuration (baseline accuracy plus adapter contribution) are specified in Table 2 of ANSI/TIA-1152.
    - 1) Level IIe – Category 5e (100MHz)
    - 2) Level III – Category 6 (250 MHz)
    - 3) Level IV – Category 6A (500MHz)
  - b. The test plug shall fall within the values specified in ANSI/TIA-568-C Annex C for NEXT, FEXT and Return Loss.
  - c. The tester shall be within the calibration period recommended by the vendor in order to achieve the vendor-specified measurement accuracy.
  - d. The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester interface adapters. In order to deliver optimum accuracy, preference is given to a permanent link interface adapter for the tester that can be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface. The contractor shall provide proof that the interface has been calibrated within the period recommended by the vendor. To ensure that normal handling on the job does not cause measurable Return Loss change, the adapter cord cable shall not be of twisted-pair construction.
  - e. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests (detailed in Section 4.2.2 of ANSI/TIA-1152). Any Fail or Fail\* result yields a Fail for the link-under-test. In order to achieve an overall Pass condition, the results for each individual test parameter must Pass or Pass\*.
  - f. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter. The test result of a parameter shall be marked with an asterisk (\*) when the result is closer to the test limit than the accuracy of the field tester. The field tester manufacturer must provide documentation as an aid to interpret results marked with asterisks.
2. Measurement Capabilities
  - a. Wire Map
  - b. Length
  - c. Propagation Delay
  - d. Delay Skew
  - e. DC Loop Resistance
  - f. DC Resistance Unbalance within a pair
  - g. DC Resistance Unbalance between pairs
  - h. Insertion Loss
  - i. NEXT (Near-End Crosstalk)
  - j. PS NEXT (Power Sum Near-End Crosstalk)
  - k. ACR-N (Attenuation to Crosstalk Ratio Near-End)
  - l. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
  - m. ACR-F (Attenuation to Crosstalk Ratio Far-End)
  - n. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
  - o. Return Loss
  - p. TCL (Transverse Conversion Loss)
  - q. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
  - r. Time Domain Reflectometer
  - s. Time Domain Xtalk Analyzer
  - t. PS ANEXT (Power Sum Alien Near-End Crosstalk)
  - u. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)

- v. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
  - w. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
- C. Fiber Optic Cable Test Equipment:
1. The test equipment shall be within the calibration period recommended by the manufacturer.
  2. Fiber optic test jumpers and adapters shall be of high quality and shall not show excessive wear.
  3. Optical Loss Test Set (OLTS):
    - a. An OLTS is comprised of two components: an optical light source and an optical power meter. After making a reference measurement, the source and meter are located at opposite ends of the fiber under test. A source and meter may be contained within the same package to enable bi-directional testing without swapping end test equipment.
    - b. Multimode optical fiber light source:
      - 1) Dual LED light sources with central wavelengths of 850nm ( $\pm 30$ nm) and 1300nm ( $\pm 20$ nm).
      - 2) Output power of -20dB minimum.
      - 3) 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 (as described in clause E.7 of ANSI/TIA-568-C.0) with a Category 1 light source.
    - c. Singlemode optical fiber light source:
      - 1) Dual laser light sources with central wavelengths of 1310nm ( $\pm 20$ nm) and 1550nm ( $\pm 20$ nm).
      - 2) Output power of -10dB minimum.
    - d. Power Meter:
      - 1) 850 nm, 1300/1310 nm, and 1550 nm wavelength test capability.
      - 2) Power measurement uncertainty of  $\pm 0.25$  dB.
      - 3) Store reference power measurement.
      - 4) Save at least 100 results in internal memory.
      - 5) PC interface (serial or USB).
  4. Optical Time Domain Reflectometer (OTDR):
    - a. Internal non-volatile memory and removable memory device with at least 16MB capacity for results storage.
    - b. Serial and USB ports to transfer data to a PC.
    - c. Multimode OTDR:
      - 1) Wavelengths of 850nm ( $\pm 20$ nm) and 1300nm ( $\pm 20$ nm).
      - 2) Event deadzones of 3.7 m maximum at 850 nm and 1300 nm.
      - 3) Attenuation deadzones of 10m maximum at 850nm and 13m maximum at 1300nm.
      - 4) Distance range at least 2,000m.
      - 5) Dynamic range at least 10dB at 850nm and 1300nm.
    - d. Singlemode OTDR:
      - 1) Wavelengths of 1310 nm ( $\pm 20$  nm) and 1550 nm ( $\pm 20$  nm).
      - 2) Event dead zones of 3.5 m maximum at 1310 nm and 1550 nm.
      - 3) Attenuation dead zones of 10 m maximum at 1310 nm and 12 m maximum at 1550 nm.
      - 4) Distance range not less than 10,000 m.
      - 5) Dynamic range at least 10 dB at 1310 nm and 1550 nm
  5. Fiber Microscope:

- a. Magnification of 200X or 400X for endface inspection
  - b. Optional requirements:
    - 1) Video camera systems are preferred.
    - 2) Camera probe tips that permit inspection through adapters are preferred.
    - 3) It is preferable to use test equipment capable of saving and reporting the end face image.
  - 6. Integrated OLTS, OTDR and fiber microscope:
    - a. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.
- D. Coaxial Cable Test Equipment:
- 1. Capacitance Meter:
    - a. Range: 1 nanofarad to 9,999 microfarads.
    - b. Accuracy:  $\pm 1.5\%$  or better.
  - 2. DCR Ohms Meter:
    - a. Range: .01 ohms to 40 megaohms.
    - b. Resolution:  $\geq .1$  ohm.
    - c. Accuracy:  $\pm .4\%$  or better.
  - 3. Cable Loss Meter:
    - a. RF Signal Generation:
      - 1) Range: 1-2000 megahertz.
      - 2) Resolution: 1 megahertz or better.
      - 3) Output level capability: 1dBmV to  $\geq 20$ dBmV.
    - b. Spectrum Analysis:
      - 1) Range: 1-2000 megahertz.
      - 2) Resolution: 1 megahertz or better.
    - c. Loss Measurement Resolution:
      - 1) .1dBmV or better.
    - d. Data Storage & Recall:
      - 1) Capable of storing test results from  $\geq 100$  individual cables.
      - 2) Serial and USB ports to transfer data to a PC.
  - 4. Copper Time-Domain Reflectometer (TDR):
    - a. Adjustable Pulse Width Settings.
    - b. Programmable nominal velocity of propagation (NVOP) to match cable under test.
    - c. NVOP Range: .30 to .99, in .01 increments
    - d. Measurement Accuracy: 1% or better.
    - e. Measurement Range:  $\geq 30,000$ -feet @ 64% NVOP.

## **PART 3 - EXECUTION**

### **3.1 UTP CABLE TESTING**

- A. General:
- 1. Field test UTP cabling upon completion of the installation.
  - 2. Every cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA-568-C.2 "Commercial Balanced Twisted-Pair Telecommunications Cabling and Components Standard."
  - 3. The installed twisted-pair horizontal links shall be tested from the MDF/IDF (ER/TR) in the telecommunications room to the telecommunication wall outlet in the work area against the "Permanent Link" performance specification.
  - 4. One hundred percent of the installed cabling links must be tested and must pass the requirements of the standards mentioned above and as further detailed in Part 3. Any

failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for links shall be provided in the test results documentation (below).

5. Field-test instruments shall have the latest software and firmware installed.
6. Link test results from the Test Equipment shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
7. Testing shall be performed on each cabling segment (panel to panel, panel to connector or connector to connector).
8. Testing of the cabling shall be performed using high-quality test cords of the same Category and manufacturer as the cabling under test.

**B. Performance Test Parameters – Category 5e, Category 6 and Category 6A (Augmented Category 6):**

1. The field test specifications are defined in ANSI/TIA-568-C.2 “Commercial Balanced Twisted-Pair Telecommunications Cabling and Components Standard.”
2. The test of each link shall contain the following parameters as detailed below.
  - a. Category 5e: In order to pass the test, measurements at each frequency in the range from 1 MHz through 100 MHz must meet or exceed the limit value determined in the above-mentioned standard.
  - b. Category 6: In order to pass the test, measurements at each frequency in the range from 1 MHz through 250 MHz must meet or exceed the limit value determined in the above-mentioned standard.
  - c. Category 6A (Augmented Category 6): In order to pass the test, measurements at each frequency in the range from 1 MHz through 500 MHz must meet or exceed the limit value determined in the above-mentioned standard.
3. Wire Map:
  - a. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
    - 1) Continuity to the remote end
    - 2) Shorts between any two or more conductors
    - 3) Reversed pairs
    - 4) Split pairs
    - 5) Transposed pairs
    - 6) Distance to open on shield
    - 7) Any other miss-wiring
  - b. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used.
4. Length:
  - a. The length of each balanced twisted pair shall be recorded.
  - b. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
  - c. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.
5. Propagation Delay:
  - a. Is the time it takes for a signal to reach the end of the link.
  - b. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
  - c. The propagation delay of each balanced twisted pair shall be recorded.

- d. Is not to exceed 498 ns per ANSI/TIA-568-C.
- e. This measurement is to be performed for each of the four wire pairs.
- f. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay. The report shall include the propagation delay value measured as well as the test limit value.
6. Delay Skew
  - a. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
  - b. The delay skew of each balanced twisted pair shall be recorded.
  - c. Is not to exceed 44 ns per ANSI/TIA-568-C.2.
  - d. This parameter shows the difference in propagation delay between the four wire pairs. The pair with the shortest propagation delay is the reference pair with a delay skew value of zero.
  - e. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay (the longest propagation delay). The report shall include the delay skew value measured as well as the test limit value.
7. DC Resistance
  - a. Often reported as Resistance, is the loop resistance of both conductors in the pair.
  - b. Cat 5e and Cat 6
    - 1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.
  - c. Cat 6A
    - 1) The DC Resistance shall be reported for all four pairs.
    - 2) Is not to exceed 21  $\Omega$  for all four pairs per ANSI/TIA-568-C.2.
8. DC Resistance Unbalance within a pair
  - a. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
  - b. Cat 5e and Cat 6
    - 1) Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all four pairs.
  - c. Cat 6A
    - 1) The DC Resistance Unbalance within a pair shall be reported for all four pairs.
    - 2) Is not to exceed 200 m $\Omega$  or 3%, whichever is the greatest per ANSI/TIA-568-C.2.
9. DC Resistance Unbalance between pairs (Cat 6A)
  - a. Is the difference in DC parallel resistance of the conductors of a pair compared to the DC parallel resistance of another pair, given in the formula below:
 
$$Resistance\_Unbalance_{Between\_pairs} = \left( \frac{|R_{p1} - R_{p2}|}{R_{p1} + R_{p2}} \right) 100\%$$

Where:

$R_{p1}$  is the DC parallel resistance of the conductors of a pair.

1)  $R_{p2}$  is the DC parallel resistance of the conductors of another pair.
  - b. The DC Resistance Unbalance shall be reported for the following pairs
    - 1) 1,2-3,6
    - 2) 1,2-4,5
    - 3) 1,2-7,8
    - 4) 3,6-4,5
    - 5) 3,6-7,8
    - 6) 4,5-7,8
  - c. Is not to exceed 200 m $\Omega$  or 7.5%, whichever is the greatest.
10. Insertion Loss (Attenuation):
  - a. Insertion Loss is a measure of signal loss in the permanent link or channel. The term "Attenuation" has been used to designate "Insertion Loss." Insertion Loss shall be tested from 1 MHz through the frequency range identified above for the category-rating requirements, in maximum step size of 1 MHz. Measure insertion loss at the



same frequency intervals as NEXT Loss in order to provide a more accurate calculation of the Attenuation-to-Crosstalk ratio (ACR) parameter.

- b. Minimum test results documentation (summary results): Identify the worst wire pair (1 of 4 possible). The test results for the worst wire pair must show the highest attenuation value measured (worst case), the frequency at which this worst case value occurs, and the test limit value at this frequency.
11. NEXT Loss:
- a. Pair-to-pair near-end crosstalk loss (abbreviated as NEXT Loss) shall be tested for each wire pair combination from each end of the link (a total of 12 pair combinations). This parameter is to be measured from 1 through the frequency range identified above for the category-rating requirements. NEXT Loss measures the crosstalk disturbance on a wire pair at the end from which the disturbance signal is transmitted (near-end) on the disturbing pair. The maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst case NEXT margin and the wire pair combination that exhibits the worst value of NEXT (worst case). NEXT is to be measured from each end of the link-under-test. These wire pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
  - c. Table 1 – Maximum frequency step size as defined in ANSI/TIA-1152
  - d.

Frequency Range (MHz)	Maximum Step size (MHz)
1 – 31.25	0.15
31.26 – 100	0.25
100 – 250	0.50
250 – 500	1.00

12. PS NEXT Loss:
- a. Power Sum NEXT Loss shall be evaluated and reported for each wire pair from both ends of the link under-test (a total of eight results). PS NEXT Loss captures the combined near-end crosstalk effect (statistical) on a wire pair when other pairs actively transmit signals. Like NEXT this test parameter must be evaluated from 1 through the frequency range identified above for the category-rating requirements, and the step size may not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PS NEXT. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
13. ACR-N Loss, pair-to-pair:
- a. Attenuation Crosstalk Ratio Near-end is calculated from the pair-to-pair NEXT Loss. It shall be measured for each wire-pair combination from both ends of the link under-test. NEXT Loss measures the crosstalk disturbance on a wire pair at the close end (near-end) from which the transmitter emits the disturbing signal on the disturbing pair. NEXT is measured to compute ACR-N Loss that must be evaluated and reported in the test results. ACR-N measures the relative strength of the near-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire pair combinations. ACR-N is to be measured from 1 through the frequency range identified above for the category-rating requirements,



- and the maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.
- b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR-N. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
14. PS ACR-N Loss:
- a. Power Sum Attenuation Crosstalk Ratio Near-end is a calculated parameter that combines the effect of the NEXT disturbance from three wire pairs on the fourth one. This test yields eight wire-pair combinations. Each wire-pair is evaluated from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
15. ACR-F Loss, pair-to-pair:
- a. Attenuation Crosstalk Ratio Far-end is calculated from the pair-to-pair FEXT Loss. It shall be measured for each wire-pair combination from both ends of the link under-test. FEXT Loss measures the crosstalk disturbance on a wire pair at the opposite end (far-end) from which the transmitter emits the disturbing signal on the disturbing pair. FEXT is measured to compute ACR-F Loss that must be evaluated and reported in the test results. ACR-F measures the relative strength of the far-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire pair combinations. ACR-F is to be measured from 1 through the frequency range identified above for the category-rating requirements, and the maximum step size for FEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR-F. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
16. PS ACR-F Loss:
- a. Power Sum Attenuation Crosstalk Ratio Far-end is a calculated parameter that combines the effect of the FEXT disturbance from three wire pairs on the fourth one. This test yields eight wire-pair combinations. Each wire-pair is evaluated from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.
17. Return Loss:
- a. Return Loss (RL) measures the total energy reflected on each wire pair. Return Loss is to be measured from both ends of the link-under-test for each wire pair. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
  - b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for

Return Loss. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

18. **TCL (Transverse Conversion Loss)**
  - a. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
  - b. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
  - c. Both worst case and worst margins shall be reported in both directions for all four pairs.
  - d. Cat 5e and Cat 6
    - 1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.
  - e. Cat 6A
    - 1) Is not to exceed the Category 6A limits found ANSI/TIA-568-C.2.
19. **ELTCTL (Equal Level Transverse Conversion Transfer Loss)**
  - a. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
  - b. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
  - c. Both worst case and worst margins shall be reported in both directions for all four pairs.
  - d. Cat 5e and Cat 6
    - 1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.
  - e. Cat 6A
    - 1) Is not to exceed the Category 6A limits found ANSI/TIA-568-C.2.

**C. UTP Cable Test Result Documentation:**

1. The test results/measurements shall be transferred into a database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred unaltered, i.e., "as saved in the tester" at the end of each test and that these results cannot be modified at a later time.
2. The database for the completed job shall be stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.
3. A paper copy of the summary test results shall be provided that lists the links that have been tested with the following summary information:
  - a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
  - b. The overall Pass/Fail evaluation of the link-under-test including the NEXT Headroom (overall worst case) number.
  - c. The date and time the test results were saved in the memory of the tester.
4. General Information to be provided in the electronic data base with the test results information for each link:
  - a. The identification of the customer site as specified by the end-user.
  - b. The identification of the link in accordance with the naming convention defined in the overall system documentation.
  - c. The overall Pass/Fail evaluation of the link-under-test.
  - d. The name of the standard selected to execute the stored test results.
  - e. The cable type and the value of NVP used for length calculations.
  - f. The date and time the test results were saved in the memory of the tester.
  - g. The brand name, model and serial number of the tester.
  - h. The identification of the tester interface.

- i. The revision of the tester software and the revision of the test standards database in the tester.
  - j. The test results information must contain information on each of the required test parameters that are listed and detailed above.
- 5. In-Link (In-Channel) Test Results Data. The detailed test results data to be provided in the electronic database must contain the following information:
  - a. For each of the frequency-dependent test parameters, the value measured at every frequency during the test is stored. The database program must be able to process the stored results to display and print a color graph of the measured parameters. Software must also provide a summary numeric format in which some critical information is provided numerically as defined by the summary results (minimum numeric test results documentation) as outlined above for each of the test parameters.
    - 1) Length: Identify the wire-pair with the shortest electrical length, the value of the length rounded to the nearest 0.1 m and the test limit value.
    - 2) Propagation delay: Identify the pair with the shortest propagation delay, the value measured in nanoseconds (ns) and the test limit value.
    - 3) Delay Skew: Identify the pair with the largest value for delay skew, the value calculated in nanoseconds (ns) and the test limit value.
    - 4) Insertion Loss (Attenuation): Minimum test results documentation as identified above for the worst pair.
    - 5) Return Loss: Minimum test results documentation as identified above for the worst pair as measured from each end of the link.
    - 6) NEXT, ACR-F: Minimum test results documentation as identified above for the worst pair combination as measured from each end of the link.
    - 7) PS NEXT and PS ACR-F: Minimum test results documentation as identified above for the worst pair as measured from each end of the link.

### **3.2 OPTICAL FIBER CABLE TESTING**

- A. General
  - 1. Testing Tiers requirements are as described below, unless indicated otherwise or otherwise required by the Owner.
  - 2. Every fiber optic cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
  - 3. One hundred percent of the installed cabling links must be tested and must pass the requirements as specified within this document. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for links shall be provided in the test results documentation (below).
  - 4. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests.
  - 5. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.
    - a. Loss shall not exceed calculated link loss.
  - 6. Tests shall be documented, including OLTS dual wavelength attenuation measurements for multimode and singlemode links and channels and OTDR traces and event tables for multimode and singlemode links and channels.
  - 7. 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.
  - 8. Field-test instruments shall have the latest software and firmware installed.

9. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
  10. Fiber end faces shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.
    - a. End face images shall be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.
  11. Testing shall be performed on each cabling segment (connector to connector).
  12. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.
  13. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.
- B. Performance Test Parameters:**
1. Three tiers of certification are available that vary in thoroughness of infrastructure analysis.
    - a. Tier 1: optical loss testing
    - b. Tier 2: optical loss and OTDR testing
    - c. Tier 3: optical loss and OTDR testing and magnified endface inspection
  2. Optical loss testing (Tiers 1, 2 and 3):
    - a. Backbone link:
      - 1) Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper or the equivalent method.
      - 2) Singlemode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method.
      - 3) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
      - 4) Use the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1 or the equivalent method. Follow the procedures established by these standards or application notes to accurately conduct performance testing.
      - 5) Fiber tests from the same cable between the same 2 points shall not vary over .25db from each other.
  3. OTDR Testing (Tiers 2 and 3):
    - a. Fiber links shall be tested at the appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss..
      - 1) Multimode: 850nm and 1300nm
      - 2) Singlemode: 1310nm and 1550nm
    - b. Each fiber link and channel shall be tested in both directions.
    - c. A launch cable shall be installed between the OTDR and the first link connection.
    - d. A receive cable shall be installed after the last link connection.
  4. Magnified Endface Inspection (Tier 3):
    - a. Fibers shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers.
    - b. Scratched, pitted or dirty connectors shall be diagnosed and corrected.
    - c. The end face images shall be saved and included in the test documentation package.

5. Length Measurement:
    - a. The length of each fiber shall be recorded.
    - b. It is preferable that the optical length be measured using an OLTS or OTDR.
  6. Polarity Testing:
    - a. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568-C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.
- C. Fiber Optic Cable Test Result Documentation:
1. The OLTS and OTDR test result information for each link shall be recorded in the memory of the field tester upon completion of the test.
  2. The test result records saved by the tester shall be transferred into a database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee shall be made that these results are transferred to the PC unaltered (i.e., as saved in the tester at the end of each test). The popular 'csv' format (comma separated value format) does not provide adequate protection and shall not be acceptable unless specified by the end user.
  3. The database for the completed job shall be stored and delivered on CD-ROM. This CD-ROM shall include the software tools required to view, inspect, and print any selection of test reports.
  4. Circuit IDs reported by the test instrument shall match the specified label ID.
  5. Summary Test Reports: A copy of the test results shall be provided listing links that have been tested, including the following summary information.
    - a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
    - b. The overall Pass/Fail evaluation of the link-under-test
    - c. The date and time the test results were saved in the memory of the tester.
  6. General Information to be provided in the electronic data base containing the test result information for each link:
    - a. The identification of the customer site as identified by the end-user.
    - b. The operator responsible for testing.
    - c. The overall Pass/Fail evaluation of the link-under-test.
    - d. The name of the standard selected to execute the stored test results.
    - e. The value of the NVP of the cable installed (used for length calculations).
    - f. The date and time the test results were saved in the memory of the tester.
    - g. The brand name, model and serial number of the tester.
    - h. The tester software version and the revision of the test standards database in the tester.
  7. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested optical fiber must contain the following information.
    - a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.
    - b. Tier 1:
      - 1) The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).
      - 2) The link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas above.
    - c. Tier 2:
      - 1) Tier 1 test results.
      - 2) The overall OTDR loss (attenuation) and length.
      - 3) The OTDR event loss at each wavelength and event location.
      - 4) The OTDR trace at each wavelength.
    - d. Tier 3:

- 1) Tier 1 and 2 test results.
- 2) A picture of the magnified connector endface.
- 3) The pass status based upon visual inspection.

### **3.3 COAXIAL CABLE TESTING**

- A. Test every cable individually. The following tests shall be conducted and the results recorded and submitted:
  1. Visual Inspections:
    - a. Conduct a visual inspection of the center conductor at each end of each cable. Verify that the center conductor does not have any visible nicks.
  2. Mechanical retention of connectors:
    - a. Verify F-Connectors each can withstand at least 35 pounds of direct pulling force for 2-seconds.
    - b. Verify hardline connectors shall be verified to withstand at least 100 pounds of direct pulling force for 2-seconds.
    - c. Verify that other connector types used withstand 90% of their manufacturer rated retention strength for 2-seconds.
  3. Cable measurements:
    - a. Length of cable. Determine length through the use of physical cable markings and through the use of a TDR calibrated for the cable under test.
    - b. DC Loop Resistance: Short the center conductor and shield at the station outlet end of the cable using a premade thread on 0-ohm shunt. Measure and record the loop resistance of the cable at the opposite end of the cable.
    - c. DC Resistance to Ground. Measure and record the DCR between each cable conductor (center and shield) and the nearest telecommunications grounding bus bar. This measurement shall occur after the telecommunications grounding system has been tested.
    - d. Attenuation by Frequency: Sweep the cable from 1 MHz to 1 GHz and record the attenuation results. Quantify the results in table-form in at least the following frequencies: 1, 5, 10, 50 megahertz, and 100 to 2000 megahertz in 50 megahertz increments.
    - e. Cable capacitance. With no load connected at one end of the cable connect a capacitance meter to the opposite end. Measure and record the total center-conductor- to-shield capacitance.
- B. Conduct, coordinate and supply cable test data to parties supplying or installing products that will connect to and use the coaxial cabling. Timing is critical as these parties may need to perform calculations based on test values prior to procurement and installation of certain products.

### **3.4 ACCEPTANCE OF TEST RESULTS**

- A. A representative of the end-user may at their discretion select a random sample of five percent of the installed links. The representative (or his authorized delegate) shall test these randomly selected links, and the results shall be stored in accordance with this Section. The results obtained shall be compared to the data provided by the installation contractor. If more than two percent of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the end-user representative shall repeat 100-percent testing at no cost to the Owner.



- B. Installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in this Section. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for links and channels shall be provided in the test results documentation in accordance with this Section.
- C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

**END OF SECTION 27 0810**



**SECTION 27 1116**

**CABINETS, RACKS, FRAMES AND ENCLOSURES**

**PART 1 - GENERAL**

**1.1 SUBMITTALS**

- A. Product Data:
  - 1. Product Datasheets.
  - 2. Bill of Materials (BOM):
    - a. At the top of each BOM list, identify the following:
      - 1) Rack Device.ID.
      - 2) Name and number of the space where the rack is located.
      - 3) Name of the systems the rack supports.
      - 4) Rack type.
    - b. Enumerate the quantity, brand, model and description of the rack and each option and accessory being furnished with the rack (e.g., sides, casters and fans).
- B. Shop Drawings:
  - 1. Enlarged plans of the spaces housing equipment racks.
    - a. Plans shall call out the Type and Device ID of the rack.
- C. Closeout Submittals:
  - 1. Product data.
  - 2. As-built drawings:
    - a. Enlarged plan depicting the as-installed locations of the racks.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Where the term "equipment rack" or "rack" is used, in either the singular or plural form, it refers generically to products that are designed for and normally used to house and/or mount 19-inch, 23-inch and 25-inch EIA standard rack mounted equipment. Racks come in multiple forms, sizes, finishes and styles.
  - 2. Where asterisks (\*) are used in part numbers, they represent alphanumeric variables. These variables typically represent that portion of a model or product number that must be established when ordering product based upon the size, color, accessories and other information specified.

**1.3 COORDINATION**

- A. Review and coordinate the sizes, quantity, and location of racks/cabinets/enclosures to ensure they will adequately support the work of this Division and Division 28 Systems (where applicable).
  - 1. Coordinate requirements of all systems to provide a coordinated and usable installation.

**1.4 SYSTEM DESCRIPTION**

- A. Furnish and install all Equipment Racks (see "Definitions"), accessories and products identified in this section, and as shown on the Drawings, and as additionally required to support the installation of systems and equipment specified in other related sections.
  - 1. Mount securely as specified and shown.
- B. Provide all rack hardware and accessories as specified.
  - 1. Provide in quantities as shown on the Drawings and as specified.
- C. Provide Rack Bus Bar (RBB) on each Rack.

**PART 2 - PRODUCTS****2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.
- B. Accessories furnished for equipment racks shall be as manufactured from the same manufacturer as the rack served, except where otherwise indicated.
- C. Black shall be the default color for racks. Provide alternate colors where specified.
- D. Racks that are located adjacent to one another shall be matching size, color, fit and finish except where otherwise indicated.
- E. Rack sizes. Unless another size of rack is identified in a schedule or indicated on the Drawings, provide the largest RU rack size option available of the Type specified, if another RU size is not defined as the default size.
- F. Additional rack accessories:
  - 1. Refer to the Drawings for additional requirements for rack assemblies.
  - 2. Provide additional manufacturer recommended accessories for installation of products specified.
- G. Rack Side Panels:
  - 1. Where equipment racks utilize accessory side panels, and where such racks are detailed on the Drawings to be ganged together, only one set of side panels is required per model group that is installed adjacent.
    - a. Where more than one depth of enclosed cabinet is utilized in a row, side panels shall be provided between the different depths.

**2.2 SUBSTITUTION LIMITATIONS**

- A. Approved qualifying manufacturer status notwithstanding, substitute equipment racks may not differ in exterior physical dimensions as compared to the specified equipment racks by more than  $\pm 3/4$  inch in any dimension, without pre-bid model-specific review and approval. Substitute racks with dimensions that differ greater than this shall not be considered after award of the Contract.

**2.3 EQUIPMENT RACKS**

- A. Cabinet Types, Portable:
1. Manufacturers: Subject to compliance with the requirements, provide the basis of design product or a comparable product by one of the following manufacturers:
    - a. Middle Atlantic

**2.4 RACK ACCESSORIES**

- A. Manufacturers: Subject to compliance with the requirements, provide the basis of design product or a comparable product by one of the following manufacturers:
1. Middle Atlantic Products.
  2. Atlas Sound.
  3. Raxxess / Chief.
  4. Lowell Manufacturing.
  5. Hubbell.
  6. Hoffman.
  7. X-Mark.
  8. Chatsworth.
  9. Ortronics/Legrand.
  10. Great Lakes Case & Cabinet.
  11. Panduit
  12. IT Watchdog
- B. Storage Drawer:
1. Construction: Steel.
    - a. Greater than or equal to 20-gauge drawer bottom.
    - b. Greater than or equal to 18-gauge face.
    - c. Greater than or equal to 16-gauge top and sides.
  2. Finish: Black powder coat.
  3. Available in the following standard vertical RU sizes: 1, 2, 3, and 4.
  4. Depth, usable: 13.43 inches.
  5. Depth, overall: 15.00 inches.
  6. Height, overall: 1.75 to 7.00 inches, RU dependent.
  7. Width, usable: 15.09 inches.
  8. Width, overall: 19.00 inches.
  9. Weight capacity: Greater than or equal to 50lbs.
  10. Integral horizontal support rail system on one (1) RU size designed to enable rear support by attachment to the rear rack rails of equipment rack.
  11. Ball-bearing drawer slides.
  12. Cable entry hole/slot in rear of drawer.
  13. Key lock option (KYLK), where designated.
  14. Latch option (LATCH), where designated.

15. Basis of Design: Middle Atlantic UD\*.
16. Quantity: As indicated on the Drawings.

**C. Filler Panels:**

1. General:
  - a. Panel mix: Provide mixture of vent and blank-type filler panels as required to ensure satisfactory air-flow and heat dissipation.
  - b. Sizes: Provide filler panels in sizes not exceeding two (2) RU, except where shown on the Drawings.
  - c. Quantity: Provide filler panels to occupy all unused mounting spaces of the front rack rail of racks.
2. Vent-Type:
  - a. Construction: 16-gauge steel.
  - b. Finish: Flat black powder coat.
  - c. Ventilation: Vertical vent slots.
  - d. Flanged upper and lower horizontal edges for rigidity.
  - e. Size: Available sizes from one (1) to two (2) RU.
  - f. Basis of Design: Middle Atlantic EVT-\* Series.
3. Blank-Type:
  - a. Construction: 16-gauge steel.
  - b. Finish: Flat black powder coat.
  - c. Ventilation: None, solid face.
  - d. Flanged upper and lower edges for rigidity.
  - e. Sizes: Available sizes from one (1) to six (6) RU.
  - f. Basis of Design: Middle Atlantic SB-\* Series.

**D. Rack Mount Shelves, for Audio, Video, RF, Security and other system racks:**

1. Construction: 16-gauge steel.
2. Finish: Flat black powder coat.
3. Ventilated shelf (2 to 4 RU only).
4. Height: Available in standard sizes from 1 to 4 RU.
5. Usable Depth:
  - a. 1RU: 10.7 inches.
  - b. 2 to 4RU: 15 inches.
6. Basis of Design:
  - a. 1 RU: Middle Atlantic U\* Series.
  - b. 2 to 4 RU: Middle Atlantic U\*V Series.
7. Quantity: As indicated on the Drawings.

**E. Rack Mounting Screws:**

1. Truss-type screw head.
2. Black finish.
3. Matching size and color nylon protective washer.
4. For Racks with #10-32 threaded rack rails.
  - a. #10-32 thread.
  - b. Basis of Design: Middle-Atlantic model HP.
    - 1) Quantity: Three (3) Phillips-drive screw/per RU/per rack.
  - c. Basis of Design: Middle-Atlantic model HSK.
    - 1) Quantity: One (1) Square-post security drive/per RU/per rack.
5. For Racks with #12-24 threaded rack rails.
  - a. Basis of Design: Middle Atlantic model HP-24.
  - b. Quantity: Four (4) Phillips-drive screw/per RU/per rack.
6. For Racks with 6MM cage-nut rack rails.

- a. Basis of Design: Middle-Atlantic model HP-6MM.
- b. Quantity: Four (4) Phillips-drive screw/per RU/per rack.

- F. Grounding Busbar:
  - 1. Solid bare copper.
  - 2. Cross sectional area: 0.375 square inches minimum (typically 0.25 inches thick by 1.5 inches wide).
  - 3. Length: Equivalent to the vertical RU of the rack served.
  - 4. Drilled and tapped #10 holes for ground cable connections.
  - 5. Screws: Supplied with #10 copper machine-threaded screws, one (1) per RU.
  - 6. Quantity: One (1) per equipment rack; additional units where indicated.

## **2.5 CABLE MANAGEMENT**

- A. Lacing Strips:
  - 1. Horizontally Mounted:
    - a. Designed for mounting to rear rack rails.
    - b. Solid or perforated bar construction, designed for dressing and supporting wires that route horizontally between sides of rack and from sides of racks to mounted equipment.
    - c. Available in various shapes and sizes to accommodate a wide variety of cable types, bundle sizes, and rack equipment configurations.
    - d. Basis of Design: Middle Atlantic LBP-\*\*\*\*. Provide specific models to suit the application. Coordinate with equipment installers.
    - e. Quantity: Minimum one (1) per each RU of cable termination panels.
  - 2. Vertically Mounted:
    - a. Available in various lengths to match the number of RUs of the rack served.
    - b. Perforated strip designed to accommodate types of wire ties, including hook-and-loop type.
    - c. Basis of Design: Middle Atlantic model LACE-\*\*-OP, sized to match rack RU.
    - d. Quantity: Two (2) per rack, additional units where indicated.
- B. Wire Management Panels:
  - 1. Manufacturers: Subject to compliance with the requirements, provide the basis of design product or a comparable product by one of the following manufacturers:
    - a. Middle Atlantic Products
    - b. Hubbell.
    - c. Leviton.
    - d. Ortronics/Legrand.
    - e. Panduit.
  - 2. Type A: Cable management panels shall be of this type unless specifically noted otherwise on the Drawings.
    - a. Rack mountable design.
    - b. Front and rear mounted horizontal metal slotted rings.
    - c. Basis of Design:
      - 1) 1 RU (1.75 inches): Middle Atlantic HCM-1DR
      - 2) 2 RU (3.50 inches): Middle Atlantic HCM-2DR
  - 3. Type B:
    - a. Rack mountable design.
    - b. Front mounted horizontal and vertical metal slotted rings.
    - c. Must be used with horizontal lacing bars.

- d. Shall not be used with vertically mounted cable managers that may interfere with side rings.
- e. Basis of Design:
  - 1) 1 RU (1.75 inches): Middle Atlantic HCM-1DV with vertical cable management rings (D-RING) on each side.
  - 2) 2 RU (3.50 inches): Middle Atlantic HCM-2DV with vertical cable management rings (D-RING) on each side.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Coordinate with each party providing product that will be housed within the racks. Review rack configurations to ensure they complement the systems being provided.
- B. Coordinate the delivery and installation to meet the workflow and schedules of parties reliant upon the product for their portion of the Work.

### **3.2 INSTALLATION**

- A. Equipment Racks:
  - 1. General:
    - a. Secure fixed-position, non-portable racks using removable threaded fasteners to prevent from moving or tipping.
    - b. Secure racks without casters to the floor allowing a 36-inch minimum clearance between the rearmost part of the rack and the nearest obstruction. See the Drawings for additional and more stringent requirements.
    - c. Install doors, side panels and other accessories specified.
    - d. Install bushings or grommets at cable entry and exit points to protect cables.
    - e. Clean, prep and paint visible conduits using oil-based paint that matches the color of the rack.
    - f. Comply with rack manufacturers' printed instructions and guidelines for rack installation.
  - 2. Cabinet Types, Portable:
    - a. Provide casters to facilitate ease in movement.
    - b. Prep separate openings in the rack for passage of low-voltage and power cables.
- B. Rack Accessories:
  - 1. Grounding Bus Bar:
    - a. Install grounding bus bars in the rear of racks.
    - b. Coordinate location with equipment being housed within the rack and for full adjustability of the rack rails.
  - 2. Filler Panels:
    - a. Install filler panels within each equipment rack.
    - b. The size, location and ratio of blank-to-vent filler panels shall be as required to assure proper ventilation of equipment.
    - c. Mount the filler panels using approved mounting hardware, ensuring that unused spaces within the equipment rack are covered.
  - 3. Ventilation Products:

- a. Furnish and install ventilation products as specified and indicated on the Drawings. Test operation of ventilation products and adjust as necessary.
- 4. Cable Management Products:
  - a. Install horizontal and vertical cable lacing bars in locations to optimize support and grouping of cables within the equipment racks.
  - b. Mount bars using hardware recommended by the product manufacturer. Mount securely.

### **3.3 GROUNDING AND BONDING**

- A. Install a grounding busbar in each equipment rack and bond to equipment rack.

### **3.4 IDENTIFICATION**

- A. Label each rack.

**END OF SECTION 27 1116**



**SECTION 27 1126****RACK MOUNTED POWER PROTECTION AND POWER STRIPS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials.
  - 2. Product Datasheets.
- B. Shop Drawings:
  - 1. Power Distribution Diagram(s):
    - a. Depict the power products and the AC power distribution configuration for each rack:
      - 1) Identify the Device.ID for each rack.
      - 2) Include a rack layout depicting the location of power products within the rack.
      - 3) Depict UPSs, PDUs, sequencers, receptacle strips, remote power modules, modular power strips and other distribution products.
      - 4) Identify the interconnectivity between sequencers and the products the sequencer controls.
      - 5) Identify the power up and power down sequence.
- C. Closeout Submittal:
  - 1. Product Data:
    - a. Bill of Materials.
    - b. Product Datasheets.
  - 2. As-Built Drawings:
    - a. Power Distribution Block Diagram(s).

**1.2 SYSTEM DESCRIPTION**

- A. General:
  - 1. Equipment racks, furniture and enclosures that house communications and security (where applicable) equipment shall be equipped with a functional local AC power distribution system for delivery of power from the building power system to the product(s) they house.
  - 2. Each distribution system shall be sufficient to support the powered products.
  - 3. Each distribution system shall feature sufficient connectivity to accommodate each powered product, plus an additional 20-percent spare receptacle count usable for future use. Each designated "spare" outlet shall be accessible and usable without the removal or movement of existing cables, plugs or other product.
  - 4. Selected distribution systems shall feature one or more locally installed uninterruptible power supplies for maintaining power to connected equipment in the event there is a loss of incoming building power.
    - a. UPS shall be provided with SNMP and web-based communications options to monitor and control the UPS from a network management station or any PC running Microsoft Internet Explorer. Coordinate with the Owner and provide network connectivity to the UPS.

5. Communications backboards, countertops/work-surfaces and other locations where insufficient building power receptacles are present shall be equipped with local power distribution equipment with sufficient outputs to serve the locally installed equipment.
- B. Provide UPS and power distribution equipment as shown on the detail drawings and as required to protect and power communications and security equipment.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.

### **2.2 UNINTERRUPTIBLE POWER SUPPLIES (UPS)**

- A. Manufacturer: Subject to compliance with requirements, provide products from one (1) of the following manufacturers:
  - a. Liebert.
  - b. APC.
  - c. Eaton.
- B. Type A – 120V:
  1. 3kVA Size:
    - a. True on-line double conversion.
    - b. (3000VA/2700W)
    - c. Furnish with power management software.
    - d. 120VAC input and output.
    - e. Transient voltage surge suppression.
    - f. EMI/RFI Filters.
    - g. 19-inch EIA rack mounting hardware.
    - h. Six (6) NEMA 5-20R output receptacles.
    - i. One (1) NEMA L5-30R output receptacle.
    - j. 10' cord with NEMA L5-30p plug.
    - k. Provide optional web card for SNMP and web-based management.
    - l. Basis of Design: Liebert GXT4 Series.

### **2.3 POWER SEQUENCERS**

- A. Manufacturers: Subject to compliance with requirements, provide products from one (1) of the following manufacturers:
  1. Middle Atlantic Products.
  2. SurgeX.
  3. Furman Sound.
  4. Atlas Sound.
  5. Lowell Manufacturing.
- B. Type A:

1. Integrated 6-step power sequencer with integral AC power distribution outlets associated with each step.
2. One (1) un-switched rear mounted AC outlet.
3. 19-inch EIA rack mountable design.
4. Separate status indicators to indicate which outputs are active.
5. Master AC power switch.
6. Front panel sequence power on and sequence power off switch.
7. Low-voltage control inputs to enable remote control of sequencer by third-party products.
8. Adjustable dwell time for power up and power down sequences.
9. Designed to enable multiple like-models of sequencers to be wired together for increased power switching power capacity and to increase the number of discrete sequence steps available.
10. UL Listed.
11. Input Voltage: 120VAC.
12. Available 15A and 20A capacity models.
13. UL Listed.

C. Type B:

1. Dedicated power sequence controller.
2. 19-inch EIA rack mountable.
3. Separate status indicators to indicate which outputs are active.
4. Six (6) or more independent low-voltage outputs designed for controlling low-voltage controlled AC power receptacles.
5. Master AC power switch.
6. Front panel mounted sequence power on and sequence power off switch.
7. Low-voltage control inputs that enable remote control of sequencer by third-party products.
8. Adjustable dwell time for power up and power down sequences.
9. Designed to enable multiple like-models of sequencers to be wired together to increase the number of AC outlets that can be controlled and the number of discrete sequence steps available.
10. UL Listed.
11. Input Voltage: 120VAC.

## **2.4 HORIZONTALLY MOUNTED RECEPTACLE STRIPS**

A. Manufacturers: Subject to compliance with requirements, provide products from one (1) of the following manufacturers:

1. Middle Atlantic Products.
2. Hammond Manufacturing.
3. Chatsworth Products.
4. Leviton.

B. Type HB:

1. 20 Amp non-isolated ground version.
2. 19-inch EIA rack mountable.
3. Height: 1-3/4 inches.
4. Six (6) rear-mounted NEMA 5-20R receptacles.
5. No front panel receptacles.
6. 6-foot power cord with NEMA 5-20P plug.
7. Front panel master AC power switch.
8. Integral 20 Amp Circuit Breaker.
9. Basis of Design: Hammond Manufacturing 1589H6F1BKRR.

**2.5 VERTICALLY MOUNTED RECEPTACLE STRIPS**

- A. Manufacturers: Subject to compliance with requirements, provide products from one (1) of the following manufacturers:
  - 1. Middle Atlantic Products.
  - 2. Hammond Manufacturing.
  - 3. Chatsworth Products.
  - 4. Leviton.
  
- B. Type VB:
  - 1. 20 Amp capacity.
  - 2. 120VAC input.
  - 3. NEMA 5-20R receptacles (12 outlets).
  - 4. 49 to 72 inches lengths.
  - 5. 9-foot power cord with NEMA 5-20P plug.
  - 6. Manufacturer accessory mounting brackets.
  - 7. Basis of Design: Middle Atlantic PD-1220C-NS and PB-5A brackets.

**PART 3 - EXECUTION****3.1 INSTALLATION**

- A. Surge Suppression
  - 1. Where independent outboard surge suppression products are used, connect the surge-suppression products to incoming branch power first, then derive power for downstream power distribution products from the surge suppression device.
  
- B. Uninterruptible Power Supplies (UPS):
  - 1. Connect UPS units to un-switched AC building power.
  - 2. Rackmount power supply(s) and the accessory batteries that are designed for rack mounting.
  
- C. Vertical Receptacle Strips:
  - 1. In racks, mount vertical receptacle strips inside and in the rear of the rack in an accessible location that does not interfere with the mounting of the equipment served or with future mounting of equipment.
  - 2. When UPS products are present, derive power for the strips from the output receptacle(s) of the UPS.
  - 3. Mount receptacle strips securely.
  - 4. Mount strips using the accessories and hardware recommended by the manufacturer.
  
- D. Horizontal Receptacle Strips:
  - 1. In racks, mount horizontal strips to the equipment mounting rails using machine threaded fasteners.
  - 2. In rear-of-rack applications, mount receptacle strip in accessible location but out of the way in such manner as not to restrict access to the receptacles and to equipment mounted to the front rails of the rack.

**END OF SECTION 27 1126**

**SECTION 27 1323****FIBER OPTIC BACKBONE CABLING****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials (BOM).
  - 2. Product Datasheets.
- B. Quality Assurance
  - 1. Cable and connectivity manufacturers' certification of quality and performance, including:
    - a. List of manufacturers and products approved for use by the cabling and connectivity manufacturers to meet the required extended warranty registration procedures.
    - b. Warranty documentation, including cabling and connectivity manufacturers' current product warranty data and certificates of complete connectivity solution provider status for the Contractor.
- C. Shop Drawings:
  - 1. Labeling Schema.
  - 2. Backbone System Diagram.
- D. Closeout Submittals:
  - 1. Product Datasheets.
  - 2. As-Built Drawings:
    - a. Labeling Schema.
    - b. Backbone System Diagram.
  - 3. Field Quality Control / Test Results.
  - 4. Cable and connectivity manufacturers' certification of quality and performance.
    - a. Warranty documentation, including cabling and connectivity manufacturers' current product warranty data and certificates of complete connectivity solution provider status for the Contractor.
    - b. Executed warranty documentation: Site specific, supplied from the manufacturer.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. Reference Standards:
  - 1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651 and NFPA 70 for the following types:
    - a. Plenum Rated, Nonconductive: Type OFNP, complying with UL 910.
    - b. Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
    - c. Plenum Rated, Conductive: Type OFCP or OFNP, complying with UL 910.

- d. Riser Rated, Conductive: Type OFCR or OFNR, OFCP or OFNP, complying with UL 1666.
- 2. TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
- 3. TIA/EIA-569-C, or most current version, Telecommunications Pathways and Spaces.
- 4. TIA/EIA-606-B, or most current version, Administration Standard for Commercial Telecommunications Infrastructure.
- 5. TIA/EIA-607-B, or most current version, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
- 6. The most current published version of the "Telecommunications Distribution Methods Manual (TDMM)" published by the Building Industry Consulting Services International (BICSI).
- 7. The most current published version of the "Information Transport Systems Installation Methods Manual (ITSIMM)" published by the Building Industry Consulting Services International (BICSI).

### **1.3 COORDINATION**

- A. Review and coordinate the sizes, quantity, routing and spacing of pathways to ensure they will adequately support the work of this Section.
  - 1. Confirm that cables to be installed shall not exceed maximum fill capacities of raceways and shall meet the minimum requirements of Local, State and Federal laws and requirements.
- B. Coordinate layout and installation of communications cabling with Owner's telecommunications, WAN and LAN equipment and service suppliers.

### **1.4 QUALITY ASSURANCE**

- A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate marking of applicable testing agency.
- B. Prior to bid, Contractor shall be listed and shall maintain participation as part of the cabling and connectivity manufacturers' certified contractor programs. Provide documentation as outlined in Submittals.

### **1.5 DELIVERY, STORAGE AND HANDLING**

- A. Store materials in conditions endorsed by the product manufacturer.
- B. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

- C. Do not deliver or install product(s) in conditions that jeopardize the performance or manufacturer life expectancy and service life of the product.

## **1.6 WARRANTY**

- A. Additional requirements: Cabling and connectivity products manufacturers, including patch cords, shall have in place an agreement recognizing each other for execution of the warranty as specified. Performance and applications warranties shall be channel rated, including patch cords.
- B. The cable manufacturer and the connectivity products manufacturer shall have a partnership agreement established in order to provide the required warranty.
- C. Required warranty: The TIA/EIA-568-C compliant cable system shall include a minimum 15 year extended product warranty and performance/applications assurance program.

## **1.7 SYSTEM DESCRIPTION**

- A. The fiber optic backbone cabling system shall be a system of interconnections between communications rooms, main terminal spaces and entrance facilities as part of a complete communications cabling system infrastructure. The cabling system consists of cables, cross-connect enclosures, and terminations used for backbone-to-backbone cross-connection.
- B. Provide TIA/EIA-568-C compliant fiber optic backbone cabling system.
- C. Cabling
  - 1. Refer to the Drawings for types and quantities of backbone cables.
  - 2. Provide total connectivity for complete and permanent installed communications links.
  - 3. Backbone cabling cross-connects shall be located within communications rooms, entrance facilities and other locations as designated.
- D. Unless pre-approved by the Designer, provide a single, uniform and complete connectivity solution for this Section:
  - 1. Cabling and connectivity for this Section, and related structured cabling Sections (used to form a unified Structured Cabling System), shall be provided by a single manufacturer or a two manufacturer formal relationship.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.



## **2.2 FIBER OPTIC CABLE**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
1. Berk-Tek; a Nexans company (Berk-Tek).
  2. Belden CDT.
  3. CommScope, Inc. (CommScope).
  4. General Cable Technologies Corporation (General Cable).
  5. Mohawk; a division of Belden CDT (Mohawk).
  6. Superior Essex.
  7. Corning
- B. General:
1. General Performance: Comply with transmission standards in TIA/EIA-568-C when tested according to test procedures of this standard.
  2. System cables shall be code compliant and UL/NEC rated for the location, manner, and environmental conditions in which the cables are installed.
    - a. Cables that are installed in an air handling space and not installed in a totally enclosed pathway system shall be UL plenum rated.
    - b. Cables used for below grade applications, and cables used in pathways that may reasonably end up with standing water within them, shall be manufacturer rated for continuous contact with water without performance degradation or compromise in warranty.
    - c. Cables used for direct burial, aerial, or other applications shall be manufacturer rated for the application.
      - 1) Also see "Inter-Building Cabling" Section for cable alternate construction.
  3. Fiber optic backbone cables on this Project shall utilize industry standard jacket color coding to identify fiber grade.
- C. Cable Construction
1. Any fiber optic cable not of interlocking armored construction will be installed in a properly rated (plenum) inner-duct.
  2. All fiber optic cable will be properly constructed for the environmental conditions and to meet all applicable codes.
  3. Jacket:
    - a. Utilize industry standard color coding for multimode and singlemode fiber optic cable jacket colors.
    - b. Cable cordage jacket, fiber, unit and group color shall be according to TIA/EIA-568-C.
    - c. Imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
  4. The following basic construction types are recognized on this Project:
    - a. Tight buffer armored premise distribution cable
      - 1) Plenum (OFNP) rated construction unless otherwise specifically noted.
      - 2) Used in indoor pathways primarily as backbone cable.
      - 3) Fiber counts can range from 4 to 72 strands
      - 4) Hybrid SM/MM strand mix is acceptable.
      - 5) This cable construction will never be used in an outdoor or harsh environment.
      - 6) OD shall range .49"-.59"
      - 7) Basis of Design shall be General Cable XX####1PNU-ILPA
        - a) XX = optical Code; ####= Strand Count.

**D. Optical Properties**

**E. Description: Multimode, 50/125-micrometer, OM3.**

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with EIA-455-41 and EIA-455-25 for crush resistance and impact resistance.
3. Comply with TIA/EIA-492AAAC for detailed specifications.
4. Comply with TIA/EIA-568-C for performance specifications.
5. Meet or exceed ISO/IEC 11801 OM3 Grade 5 optical characteristics:
  - a. Dual window of 850 nm and 1300 nm.
  - b. Minimum Overfill Launch Bandwidth: 1500 MHz/km (EMB) at 850 nm; 500 MHz/km at 1300 nm.
  - c. Laser Launch Bandwidth: 2000 MHz/km.
  - d. Gigabit Ethernet (GbE) Distance (min.): 1000 m at 850 nm; 550 m at 1300 nm.
  - e. 10 Gigabit Ethernet (10 GbE) Distance (min.): 300 m at 850 nm.
  - f. Maximum attenuation: 3.0 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
  - g. Basis of Design shall be General Cable Code BE.

### **2.3 FIBER OPTIC CABLE TERMINATIONS AND HARDWARE**

**A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :**

1. CommScope, Inc. (CommScope).
2. Corning Cable Systems (Corning).
3. Hubbell Premise Wiring (Hubbell).
4. Leviton Mfg. Company, Inc. (Leviton).
5. Ortronics; a subsidiary of Legrand (Ortronics).
6. Panduit Corp. (Panduit).
7. 3M (3M).

**B. General Requirements for Cable Connecting Hardware:**

1. Cables shall be terminated with connecting hardware of same optical performance or higher.
2. Provide one single manufacturer for fiber optic cable termination hardware.
3. Cable hardware (i.e., connectivity) shall be part of the manufacturer's enterprise solution.

**C. Rack Mounted Fiber Optic Panel Enclosure: Modular enclosures housing multiple adapter plates, splice trays and MTP cassette modules:**

1. TIA/EIA-568-C compliant.
2. Steel: black powder coated finish.
3. Front metal door or smoked polycarbonate door, removable.
4. Rear metal cover/door, removable.
5. Rear tray capacity for splice trays.
6. Slack management spools included.
7. Accepts standard fiber optic adapter plates and cassettes.
8. EIA standard 19 inches rack rails.
9. Available in 1RU (1.75 inches), 2RU (3.50 inches) or 3RU (5.25 inches) sizes.
  - a. 1RU: Capacity for up to (3) adapter plates; up to (3) splice trays.
  - b. 2RU: Capacity for up to (6) adapter plates; up to (6) splice trays.
  - c. 3RU: Capacity for up to (9) adapter plates; up to (12) splice trays.
10. Basis of Design: Panduit FCE#U, size as indicated.
  - a. Include slide mounting kit for access, as required.
  - b. Include additional fiber management rings, as required.

- c. Include Cable clamp kits.
- D. Fiber Optic Adapter Plates: Modular adapter plates for multiple fibers and connector types fitting within rack mounted and wall mounted fiber optic panel enclosures:
  - 1. Multimode:
    - a. Individual couplers installed.
    - b. Mounts within fiber optic panel enclosures.
    - c. Six (6) duplex SC adapters accommodating twelve (12) fibers.
    - d. Provide adapter plate with couplers to match specified fiber performance.
      - 1) Provide phosphor bronze sleeves for multimode applications.
      - 2) Provide ceramic sleeves for 50/125-micrometer OM 4 and 4+ laser optimized applications.
      - 3) Utilize industry standard color coding.
    - e. Coordinate with fiber optic panel enclosure.
    - f. Provide adequate panels to terminate all fiber strands on rear of adapter plates.
- E. Fusion Splice Tray: Splice trays mounting within fiber optic panel enclosures:
  - 1. Each splice tray shall be of fusion type.
  - 2. Splices shall be enclosed in a splice tray mounted in a splice module housing or splice enclosure.
  - 3. Provide mounting hardware kits, holders and sleeves as required.
- F. Cable Connectors: Connectors for terminating fiber optic cable strands:
  - 1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A and TIA/EIA-604-12. Comply with TIA/EIA-568-C.
  - 2. SC Connector, Multimode:
    - a. Each connector shall use a U/V or adhesive/epoxy to firmly adhere the glass strand to the connector.
    - b. The connector ferrule shall be ceramic.
    - c. The connector shall provide 0.10 dB typical insertion loss or less.
    - d. Provide duplex SC clip, as required.
    - e. Provide connector to match specified fiber performance; utilize industry standard color coding.
  - 3. SC Pigtail, Multimode (Fusion Splice):
    - a. Each SC connector shall be pre-terminated on a 900 micron multimode fiber optic strand with 1m (minimum) length.
    - b. Provide pigtail to match specified fiber performance.
    - c. Utilize industry standard color coding.
    - d. The connector ferrule shall be ceramic.
    - e. The connection shall provide 0.10 dB typical insertion loss or less; 0.30 dB maximum.

## **2.4 SOURCE QUALITY CONTROL**

- A. System components shall be tested and listed by one or more United States NRTL.

**PART 3 - EXECUTION****3.1 GENERAL**

- A. Review and coordinate cabling pathways prior to pathway and cabling installation.
  - 1. Coordinate to resolve deviations, defects or other problems with pathways prior to installation. Allow adequate time for corrections so as to avoid delays to the Project completion date.
  - 2. Provide additional or supplemental TIA/EIA-569-C, or most current version, compliant pathways and cable support where required. Provide additional sleeves through walls/floors/ceilings, as necessary to route cables within buildings.
- B. Project Conditions
  - 1. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
  - 2. Do not deliver or install product(s) in conditions that jeopardize the performance or manufacturer life expectancy and service life of the product.
  - 3. Delivery, Storage and Handling
    - a. Store materials in conditions endorsed by the product manufacturer.
- C. Compliance
  - 1. Comply with NECA 1.
  - 2. Comply with TIA/EIA-568-C., including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
  - 3. Monitor cable pull tensions, and comply with BICSI ITSIMM, Chapter "Pulling Cable."
  - 4. Comply with BICSI ITSIMM, Chapter "Cable Termination Practices."
  - 5. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications."
    - a. Comply with TIA/EIA-569-C, or most current version, for pull-box sizing and length of conduit and number of bends between pull points.
    - b. Do not exceed the required fill capacity of raceways.

**3.2 ENTRANCE FACILITIES**

- A. Coordinate backbone cabling with the protectors and demarcation point provided by the communications service providers.

**3.3 INSTALLATION OF CABLES**

- A. Install cables within approved pathways. Install cables that are not otherwise required to be installed within raceway in such manner as to conceal them from view. Conceal conductors and cables in accessible ceilings, walls and floors.

- B. Provide the appropriate cable rated for the environmental conditions in which the cable is to be installed.
- C. Fiber optic cable shall be installed in a protective barrier (innerduct) with the appropriate rating for the environmental conditions.
  - 1. Any fiber optic cable not of interlocking armored construction shall be installed in a properly rated (plenum) inner-duct.
  - 2. Exception: Fiber optic cabling with plenum rated interlocking armor jacket shall not require innerduct.
- D. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
- E. Do not splice cable between terminations or junction points. Cable runs shall be continuous.
- F. Maintain complete protection of cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades.
- G. Cable routing shall follow building structure lines (parallel and perpendicular).
- H. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- I. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- J. Open-Cable Installation:
  - 1. Install cabling with horizontal and vertical cable guides in communications spaces with terminating hardware and interconnection equipment.
  - 2. Suspend cable not in a raceway, a minimum of 8 inches (200 mm) above ceilings by discrete cable supports not more than 60 inches (1524 mm) apart. Bridle rings are not permitted.
  - 3. Cable shall not be run through structural members or in contact with conduits, pipes, ducts or other similar or potentially damaging items.
- K. Provide conduit sleeves for penetrations.
  - 1. Provide conduit sleeves for cables where cables pass through walls, floors and ceilings.
  - 2. Patch and firestop around sleeves.
  - 3. Firestop the interior of the sleeves after cable installation.
  - 4. Provide the appropriate bushings on each end. Split bushings shall not be used.
  - 5. Provide waterproof sealant for penetrations in humidity controlled areas.
- L. Comply with requirements in Section 270502 "Basic Materials and Methods for Communications."
  - 1. Bundle cables within racks, ladder racks, cable trays and in discrete cable supports. Utilize reusable cable bundling hardware. Utilize plenum-rated hardware in plenum spaces.
- M. Separate cabling by service and type (i.e., voice, data, control, coaxial, fiber) prior to terminating.
  - 1. Terminate cabling on specified termination hardware in alpha-numerical order.

2. Neatly dress and securely attach cabling to the backboard and/or cabinet/rack.
  3. Provide adequate cable lengths to reach any location on the backboard or within the cabinet/rack.
  4. Bundle and support cables of this System separately from the cables of other systems.
  5. Where cables from different systems or cables with different signal types are expressly permitted by the Designer to share a common pathway, each of these cable groups shall be kept segregated to the maximum degree physically possible. Cables from different systems shall not be mixed or intertwined.
- N. Provide a minimum service loop of 5 feet at each end and 10 feet at each junction point, unless noted otherwise.
- O. Maintain (do not violate) the minimum bend radius specified by the manufacturer of the cable.
- P. At final termination, excess cable and the service loop shall be supported and stored neatly in the cable tray or ladder rack within the communications rooms.
1. Proper strain relief shall be applied to cables after installation to lessen the risk of physical damage and to provide proper aesthetic value.
- Q. Cabling within Enclosures:
1. Bundle, lace, and train cables within enclosures.
  2. Connect to terminal points with no excess and without exceeding manufacturers' limitations on bending radii.
  3. Provide and use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- R. Cable Termination:
1. Terminate every conductor; no cable shall contain unterminated elements unless otherwise indicated. Make terminations only at indicated outlets, terminals, cross-connects and patch panels.
  2. Fiber optic cabling shall be terminated using fusion-spliced, factory-polished pigtails.
  3. Fiber optic cables shall utilize factory manufactured break-out kits to protect fiber strands within fiber optic enclosures.
    - a. Provide buffer tubing on fiber strands from the connector to the cable break-out (minimum 6 inches pigtails), and secure to the cable jacket for fiber optic cables that do not have a cladding.
  4. Utilize standard positive identification color coding for multi-strand cables.

### **3.4 IDENTIFICATION**

- A. Label each end of the cable.
- B. Identify system components and cabling in compliance with TIA/EIA-606-B, or most current version.

### **3.5 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
1. Visually inspect optical fiber cabling jacket materials for NRTL certification markings.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords and labeling of components.
3. Optical fiber cable tests:
  - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- B. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report for the cables as well as a detailed report for each cable tested.
- C. Remove and replace cabling where test results indicate they do not comply with specified requirements. Retest cabling and provide documentation.
- D. End-to-end cabling shall be considered defective if it does not pass tests and inspections.
- E. Prepare and submit test and inspection reports.
- F. The Owner reserves the right to have a representative present during testing procedures. Verification testing of copper and fiber may be performed at or near Project completion by the Consultant for quality assurance.
- G. Upon verification testing, if the Consultant finds the test results do not match the Contractor's results, the Consultant or a third party may at the Owner's request retest the cabling and submit those results to the Owner and deduct the verification testing costs from the Contractor's Contract amount.

**END OF SECTION 27 1323**



**SECTION 27 1513****COPPER HORIZONTAL CABLING****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Product Datasheets.
  - 2. Bill of Materials (BOM).
  - 3. Warranty documentation, including connectivity/cabling manufacturer product warranty data and certificates of complete connectivity solution provider status for the Contractor.
  
- B. Quality Assurance
  - 1. Cable and connectivity manufacturers' certification of quality and performance, including:
    - a. List of manufacturers and products approved for use by the cabling and connectivity manufacturers to meet the required extended warranty and warranty registration procedures.
    - b. Warranty documentation, including cabling and connectivity manufacturers' current product warranty data and certificates of complete connectivity solution provider status for the Contractor.
  
- C. Shop Drawings:
  - 1. Floor Plans
  - 2. Labeling Schema.
  
- D. Closeout Submittals:
  - 1. Product Datasheets.
  - 2. As-Built Drawings:
    - a. Floorplans
    - b. Rack Elevations.
    - c. Wall Elevations.
    - d. Labeling Schema.
  - 3. Field Quality Control / Test Results.
  - 4. Cable and connectivity manufacturers' certification of quality and performance.
    - a. Warranty documentation, including cabling and connectivity manufacturers' current product warranty data and certificates of complete connectivity solution provider status for the Contractor.
    - b. Executed warranty documentation: Site specific, supplied from the manufacturer.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Consolidation Point (CP): A location for interconnection between horizontal cables extending from Telecommunications Rooms and horizontal cables extending to the communications outlet/connector. Typically used to feed office furniture or similar re-configurable areas.

2. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
3. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors. Similar function as CP except the horizontal cables are terminated with RJ45 interfaces at both ends and the cable extends to the workstation as a station attachment cable.
4. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
5. Twisted-Pair: Two individually insulated copper wires physically twisted together to form a balanced pair.
6. Twisted-Pair Cable: A multi-conductor cable comprising two or more copper conductors twisted in a manner designed to cancel electrical interference. Also called balanced twisted-pair cable.

**B. Reference Standards:**

1. TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
2. TIA/EIA-569-C, or most current version, Telecommunications Pathways and Spaces.
3. TIA/EIA-606-B, or most current version, Administration Standard for Commercial Telecommunications Infrastructure.
4. TIA/EIA-607-B, or most current version, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
5. The most current published version of the "Telecommunications Distribution Methods Manual (TDMM)" published by the Building Industry Consulting Services International (BICSI).
6. The most current published version of the "Information Transport Systems Installation Methods Manual (ITSIMM)" published by the Building Industry Consulting Services International (BICSI).

### **1.3 COORDINATION**

- A. Review and coordinate the sizes, quantity, routing and spacing of pathways to ensure they will adequately support the work of this Section.
  1. Confirm that cables to be installed will not exceed maximum fill capacities of raceways and shall meet the minimum requirements of Local, State and Federal laws and requirements.
  2. Confirm that cables to be installed within the pathways will not exceed the maximum standards-based distance limitations (90 meters (295 feet)) for horizontal cabling.
- B. Coordinate communications outlet/connector locations with the location of power receptacles at each work area. Coordinate so that power receptacles are immediately adjacent and same height.
- C. Coordinate layout and installation of communications cabling with telecommunications and LAN equipment and service suppliers.

**1.4 QUALITY ASSURANCE**

- A. Prior to bid, Contractor shall be listed and shall maintain participation as part of the cabling and connectivity manufacturers' certified contractor programs. Provide documentation as outlined in Submittals.

**1.5 DELIVERY, STORAGE AND HANDLING**

- A. Store materials in conditions endorsed by the product manufacturer.
- B. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- C. Do not deliver or install product(s) in conditions that jeopardize the performance or manufacturer life expectancy and service life of the product.

**1.6 WARRANTY**

- A. Additional requirements: Cabling and connectivity products manufacturers, including patch cords, shall have in place an agreement recognizing each other for execution of the warranty as specified. Performance and applications warranties shall be channel rated, including patch cords.
- B. The cable manufacturer and the connectivity products manufacturer shall be the same manufacturer or shall have a partnership agreement established in order to provide the required warranty.
- C. Required warranty: The TIA/EIA-568-C Category 6A - 500 MHz compliant cable system shall include a minimum 15 year extended product warranty and performance/applications assurance program.

**1.7 SYSTEM DESCRIPTION**

- A. Horizontal cabling and connecting hardware provide the means of transporting signals between the communications outlet/connector and the horizontal cross-connect located in the communications room or enclosure. The cabling and associated connecting hardware are called a "permanent link," a term that is used in the testing protocols.
- B. Provide TIA/EIA-568-C compliant 4-pair twisted pair horizontal cabling system.
  - 1. Provide Category 6A compliant horizontal cabling system.
- C. Cabling
  - 1. Refer to the Drawings for types and quantities of horizontal cables.
  - 2. Provide total connectivity for complete and permanent installed communications links.

3. The copper horizontal cabling system shall include provisions for voice/telephone, data/network, video surveillance, audio-visual, access control, building automation, control data and intrusion detection systems.
  - a. Cables may be color-coded by system. Reference the Drawings for requirements, and coordinate with the Owner for final verification.
- D. Unless pre-approved by the Designer, provide a single, uniform and complete connectivity solution for this Section:
  1. Cabling and connectivity for this Section, and related structured cabling Sections (used to form a unified Structured Cabling System), shall be provided by a single manufacturer or a two manufacturer formal relationship.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.

### **2.2 CABLING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Berk-Tek; a Nexans company (Berk-Tek).
  2. Belden CDT.
  3. CommScope, Inc. (CommScope).
  4. General Cable Technologies Corporation (General Cable).
  5. Mohawk; a division of Belden CDT (Mohawk).
  6. Superior Essex.
- B. General:
  1. General Performance: Comply with transmission standards in TIA/EIA-568-C when tested according to test procedures of this standard.
    - a. Twisted pair cable is required to have the appropriate Category classification as defined by TIA/EIA-568-C. Compliance with these electrical characteristics shall be third party verified by the manufacturer.
  2. System cables shall be code compliant and UL/NEC rated for the location, manner, and environmental conditions in which the cables are installed.
    - a. Cables that are installed in an air handling space and not installed in a totally enclosed pathway system shall be UL plenum rated.
    - b. Cables used for below grade applications, and cables used in pathways that may reasonably end up with standing water within them, shall be manufacturer rated for continuous contact with water without performance degradation or compromise in warranty.
      - 1) Cables in conduit to a floorbox in a slab on grade application shall transition to OSP rated 4 pair cables.
    - c. Cables used for direct burial, aerial, or other applications shall be manufacturer rated for the application.
      - 1) Also see "Inter-Building Cabling" Section for cable alternate construction.

3. Cables on this Project may be color-coded. See drawings for color code.

C. Twisted Pair Cable

1. Description: 100-ohm, Indoor four-pair with a thermoplastic jacket.
  - a. Comply with ICEA S-90-661 for mechanical properties.
  - b. Comply with TIA/EIA-568-C for performance specifications.
  - c. Comply with TIA/EIA-568-C, Category 6A (Augmented Category 6).
    - 1) Cable shall have two individual insulated 23 AWG solid copper conductors formed into a twisted pair.
    - 2) Cable must be constructed of one 4-pair bundle of individually insulated Unshielded Twisted Pairs (UTP).
    - 3) Nominal cable OD shall not exceed 0.300 inches.
    - 4) Basis of design shall be: General Cable GenSpeed 10000

## **2.3 CABLE TERMINATION HARDWARE**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CommScope, Inc. (CommScope).
  2. Hubbell Premise Wiring (Hubbell).
  3. Leviton Mfg. Company, Inc. (Leviton).
  4. Ortronics; a subsidiary of Legrand (Ortronics).
  5. Panduit Corp. (Panduit).
  6. 3M (Transition splices)
- B. General Requirements for Cable Connecting Hardware:
1. Comply with TIA/EIA-568-C, IDC type, with modules designed for punch-down.
  2. Cables shall be terminated with connecting hardware of same category or higher.
  3. Provide one single manufacturer for twisted pair termination hardware used together in a permanent link and whenever a Category certification is required.
  4. Cable hardware (i.e., connectivity) shall be part of the manufacturer's enterprise solution.
  5. Cable hardware shall be component rated with third-party verification for the specified Category-rated component compliance.
- C. Patch Panels
1. Configurable Patch Panel: Modular panels housing rear-mounted UTP connector jack modules which snap in and out for easy moves, adds, and changes.
    - a. Number of Positions and Connector Jacks per Field: One (1) for each four-pair UTP cable required, plus 20 -percent spare.
    - b. Comply with TIA/EIA-568-C.
      - 1) Flat modular patch panel, flush mount.
      - 2) Black steel.
      - 3) UL listed.
      - 4) Molded rear snap-in positions for category-rated modules for UTP. Refer to the Drawings for color coding requirements.
      - 5) Labeling.
      - 6) Mountable in EIA standard 19-inch rack/cabinet rails.
      - 7) 24-ports in 1.75 inches of rack space (1RU); 48-ports in 3.5 inches of rack space (2RU).
      - 8) Provide accessory strain relief bars on the rear with hook and loop ties.
      - 9) Basis of Design: Panduit CPP\*\*FMWBLY.

- D. Connector Jacks, Jack Assemblies
  - 1. Connector Jacks:
    - a. 100-ohm, balanced, twisted pair connector; four-pair, eight-position modular color-coded receptacle units with integral IDC-type terminals, component rated.
    - b. Connector jacks and jack assemblies shall be color coded by system.
      - 1) Color(s): As scheduled in the Contract Documents.

## **2.4 SOURCE QUALITY CONTROL**

- A. System components shall be tested and listed by one or more United States NRTL.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Review and coordinate cabling pathways prior to pathway and cabling installation.
  - 1. Coordinate to resolve deviations, defects or other problems with pathways prior to installation. Allow adequate time for corrections so as to avoid delays to the Project completion date.
  - 2. Provide additional or supplemental TIA/EIA-569-C compliant pathways and cable support where required. Provide additional sleeves through walls/floors/ceilings, as necessary to route cables within buildings.
- B. Project Conditions
  - 1. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
  - 2. Do not deliver or install product(s) in conditions that jeopardize the performance or manufacturer life expectancy and service life of the product.
  - 3. Delivery, Storage and Handling
    - a. Store materials in conditions endorsed by the product manufacturer.
- C. Compliance
  - 1. Comply with NECA 1.
  - 2. Comply with TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard; and TIA/E7IA-568-C.3, Optical Fiber Cabling Components Standard.
  - 3. Monitor cable pull tensions, and comply with BICSI ITSIMM, Chapter "Pulling Cable."
  - 4. Comply with BICSI ITSIMM, Chapter "Cable Termination Practices."
  - 5. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications."
    - a. Comply with TIA/EIA-569-C, or most current version, for pull-box sizing and length of conduit and number of bends between pull points.
    - b. Do not exceed the required fill capacity of raceways.
  - 6. Install faceplates and inserts furnished under Section 271543 "Faceplates and Connectors" and/or Section 271544 "Custom Faceplates, Panels and Connectors."

7. Provide the appropriate cable rated for the environmental conditions in which the cable is to be installed.

### **3.2 INSTALLATION OF CABLES**

- A. Prior to procurement and installation of the horizontal cabling system, coordinate and verify pathways provided and indicated on the Contract Documents.
  1. Coordinate and verify to ensure that horizontal cables will not exceed the maximum standards-based distance limitations (90 meters (295 feet)) for horizontal cabling. Any discrepancy shall be immediately brought to the attention of the Designer for direction.
  2. The maximum allowable total channel distance is 328 feet (100m) between equipment in the communications room and station equipment, including cable service loops, patch cables and station attachment cables.
  3. If proactive steps are not taken prior to procurement or installation, the Contractor shall be responsible for costs associated with providing the horizontal cabling system within industry-standard distance limitation parameters, including, but not limited to, additional required cabling, pathways, rough-in, equipment, communications rooms or enclosures, power and cooling requirements.
- B. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the communications outlet/connector.
- C. Bridged taps and splices shall not be installed as part of the horizontal cabling.
- D. Install cables within approved pathways. Install cables that are not otherwise required to be installed within raceway in such manner as to conceal them from view. Conceal conductors and cables in accessible ceilings, walls and floors.
- E. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
- F. Do not splice cable between terminations or junction points. Cable runs shall be continuous. Wiring shall be free from grounds, shorts, opens and reversals.
- G. Maintain complete protection of cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades.
- H. Cable routing shall follow building structure lines (parallel and perpendicular).
- I. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- J. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- K. Open-Cable Installation:
  1. Install cabling with horizontal and vertical cable guides in communications spaces with terminating hardware and interconnection equipment.



2. Suspend cable not in a raceway, a minimum of 8 inches (200 mm) above ceilings by discrete cable supports not more than 60 inches (1524 mm) apart. Bridle rings are not permitted.
  3. Cable shall not be run through structural members or in contact with conduits, pipes, ducts or other similar or potentially damaging items.
- L. Provide conduit sleeves for penetrations.
1. Provide conduit sleeves for cables where cables pass through walls, floors and ceilings.
  2. Patch and firestop around sleeves.
  3. Firestop the interior of the sleeves after cable installation.
  4. Provide the appropriate bushings on each end. Split bushings shall not be used.
  5. Provide waterproof sealant for penetrations in humidity controlled areas.
- M. Maintain (do not violate) the minimum bend radius specified by the manufacturer of the cable.
- N. At final termination, excess cable and the service loop shall be supported and stored neatly in the cable tray or ladder rack within the communications room and above the ceiling line at an accessible point at the station end.
- O. Proper strain relief shall be applied to cables after installation to lessen the risk of physical damage and to provide proper aesthetic value.
- P. Cabling within Enclosures:
1. Bundle, lace, and train cables within enclosures.
  2. Connect to terminal points with no excess and without exceeding manufacturers' limitations on bending radii.
  3. Provide and use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- Q. Comply with requirements in Section 270501 "Basic Materials and Methods for Communications."
1. Bundle cables within racks, ladder racks, cable trays and in discrete cable supports. Utilize reusable cable bundling hardware. Utilize plenum-rated hardware in plenum spaces.
- R. Separation from EMI Sources:
1. Outlet requirements where power and communications must be co-located, a voltage barrier shall be provided.
  2. Comply with BICSI TDMM and TIA/EIA-569-C recommendations for separating unshielded twisted pair (UTP) cable from potential EMI sources, including electrical power lines and equipment.
  3. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - a. Electrical Equipment Rating Less Than 2kVA: A minimum of 5 inches (127 mm).
    - b. Electrical Equipment Rating between 2 and 5kVA: A minimum of 12 inches (300 mm).
    - c. Electrical Equipment Rating More Than 5kVA: A minimum of 24 inches (610 mm).
  4. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - a. Electrical Equipment Rating Less Than 2kVA: A minimum of 2-1/2 inches (64 mm).
    - b. Electrical Equipment Rating between 2 and 5kVA: A minimum of 6 inches (150 mm).
    - c. Electrical Equipment Rating More Than 5kVA: A minimum of 12 inches (300 mm).

5. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - a. Electrical Equipment Rating Less Than 2kVA: No requirement.
    - b. Electrical Equipment Rating between 2 and 5kVA: A minimum of 3 inches (76 mm).
    - c. Electrical Equipment Rating More Than 5kVA: A minimum of 6 inches (150 mm).
  6. Separation between Communications Cables and Electrical Motors and Transformers: A minimum of 48 inches (1200 mm).
  7. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- S. Separate cabling by service and type (i.e., voice, data, control, coaxial, fiber) prior to terminating.
1. Color coding of cable and termination devices shall be coordinated and approved prior to procurement and installation.
  2. Terminate cabling on specified termination hardware in alpha-numerical order.
  3. Group connecting hardware for cables into separate logical fields.
  4. Neatly dress and securely attach cabling to the backboard and/or cabinet/rack.
  5. Provide adequate cable lengths to reach any location on the backboard or within the cabinet/rack.
  6. Bundle and support cables of this System separately from the cables of other systems.
  7. Maintain separation between cables carrying different signal types and different signal levels.
    - a. Where cables from different systems or cables with different signal types are expressly permitted by the Designer to share a common pathway, each of these cable groups shall be kept segregated to the maximum degree physically possible. Cables from different systems shall not be mixed or intertwined.
- T. Service loop:
1. Within communications rooms, provide a minimum service loop of 10 feet (3 m) , and spool the service loop in the ladder rack.
  2. At the outlet/connector, provide a minimum service loop of 2 feet (0.6096 m) , and spool and store within a discrete cable support (J-hook) above the accessible ceiling at the outlet/connector location.
- U. Cable Termination:
1. Terminate every conductor; no cable shall contain unterminated elements unless otherwise indicated. Make terminations only at indicated outlets, terminals, cross-connects and patch panels.
  2. Utilize standard positive identification color coding for multi-conductor cables.
  3. Provide 110-style IDC termination hardware unless otherwise indicated.
    - a. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
  4. Cables from the same room/space shall be terminated adjacent on termination hardware. Cables from outlets/connectors shall be terminated in alpha-numeric, sequential order, based on final room numbers.
    - a. If the communications room serves more than one floor, in addition to the requirements identified above, sequentially group the cables, by floor, on separate patch panels.

### **3.3 IDENTIFICATION**

- A. Label cables and other components in compliance with Section 270553 “Identification for Communications” for labeling requirements.
- B. Label each end of the cable.
- C. Identify system components and cabling in compliance with TIA/EIA-606-B, or most current version.

### **3.4 FIELD QUALITY CONTROL**

- A. Comply with Section 270810 “Verification Testing of Structured Cabling”.
- B. Perform tests and inspections.
  - 1. Twisted pair cabling shall be factory tested according to TIA/EIA-568-C.
  - 2. Visually inspect twisted pair jacket materials for NRTL certification marking. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.
  - 3. Visually confirm the required Category-rated marking of cables, outlets, cover plates, outlets/connectors, patch panels and other termination hardware.
  - 4. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords and labeling of components.
  - 5. Test twisted pair copper cabling for DC loop resistance, shorts, opens, intermittent faults and polarity between conductors.
    - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C. Perform tests with a tester that complies with performance requirements in “Test Instruments (Normative)” Annex, complying with measurement accuracy specified in “Measurement Accuracy (Informative)” Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
  - 6. UTP Performance Tests:
    - a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-C and 270810 “Verification Testing of Structured Cabling.”
    - b. Test cables through a Consolidation Point from workstation to patch panel.
  - 7. Final Verification Tests: Perform verification tests for twisted pair systems after the complete communications cabling and workstation outlet/connectors are installed.
  - 8. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report for the cables as well as a detailed report for each cable tested.
  - 9. Remove and replace cabling where test results indicate they do not comply with specified requirements. Retest cabling and provide documentation.
  - 10. End-to-end cabling shall be considered defective if it does not pass tests and inspections.
  - 11. Prepare and submit test and inspection reports.
- C. The Owner reserves the right to have a representative present during testing procedures. Verification testing of copper and fiber may be performed at or near Project completion by the Consultant for quality assurance.
- D. Upon verification testing, if the Consultant finds the test results do not match the Contractor’s results, the Consultant or a third party may at the Owner’s request retest the cabling and submit

those results to the Owner and deduct the verification testing costs from the Contractor's Contract amount.

**END OF SECTION 27 1513**

**SECTION 27 1544****CUSTOM FACEPLATES, PANELS AND CONNECTORS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Datasheet for each distinct device (e.g., connector, switch, lamp assembly) to be used within an assembly.
- B. Shop Drawings:
  - 1. Separate Shop Drawing for each assembly:
    - a. Clearly indicate the following:
      - 1) Device.ID of the assembly.
      - 2) Manufacturer.
      - 3) Material.
      - 4) Finish and color.
      - 5) Dimensions.
      - 6) Mounting-hole quantity, size and spacing.
      - 7) Nomenclature:
        - a) Fonts.
        - b) Font sizes.
        - c) Colors.
        - d) Line widths.
      - 8) Devices to be used: By manufacturer, model and color.

**1.2 REFERENCES**

- A. Definitions:
  - 1. Devices: Products that are assembled to the front, side, rear, top or bottom of a faceplate or panel. Devices include such items as connectors, switches, lamps, meters, faders, potentiometers and connector modules.
  - 2. Components: Passive or active electronic parts that are part of a faceplate or panel assembly.

**1.3 QUALITY ASSURANCE**

- A. Faceplate and panel manufacturers shall be in the full-time business of fabricating custom faceplates and panels for the communications industry. Contractor fabricated products shall not be permitted.

**PART 2 - PRODUCTS****2.1 GENERAL**

- A. Custom faceplates and panel assemblies shall be provided wherever pre-manufactured, stock faceplates and panel assemblies are not expressly specified within another Section.
- B. Quantities of assemblies required shall be derived from the Drawings and requirements of other Sections.
- C. Configurations shall be derived from the Drawings, from the requirements of this Section, and from requirements of other Sections of the Contract Documents that rely upon these assemblies.
- D. Assemblies shall satisfy the requirements of the systems that utilize them and shall be appropriate for the Owner's intended use.
  - 1. Where a Drawing detail is not published depicting a specific assembly configuration, follow the guidelines set forth in this Section, in conjunction with Drawing notes and requirements of the system served, guide the layout of the assemblies provided. Contractor provided assemblies shall feature the same fit, finish and level of detail as assemblies that are detailed on the Drawings. Seek the express direction of the Designer.

**2.2 FACEPLATES AND PANELS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
  - 1. Panel Crafters (Liberty Wire and Cable).
  - 2. Pro-Co Sound.
  - 3. Rapco.
  - 4. RCI Custom Products.
  - 5. Whirlwind.
  - 6. Wireworks Corporation.
- B. Material:
  - 1. Stainless Steel.
- C. Material Thickness:
  - 1. Stainless Steel: 0.030 inch to 0.045 inch.
- D. Finish:
  - 1. Wall Mounted: Clear Stainless.
  - 2. Ceiling Mounted: Clear Stainless.
  - 3. Floor Box: Clear Stainless.
  - 4. Rack Mounted: Black.
- E. Mounting Holes:
  - 1. Plates of standard and oversized electrical gang sizes shall be provided with countersunk holes appropriate for accommodating trade-standard screw sizes. Holes shall be spaced to mate with the box, substructure and devices.

2. Provide quantity of holes depicted on details and additionally as necessary to securely attach the faceplate.
- F. Bracing:
1. Supplemental metal bracing shall be provided on the rear of faceplates and panels to ensure that during normal use, the faceplate or panel does not deflect more than 1/32 of an inch when inserting and removing a connector, or when operating a device.
  2. Supplemental metal bracing shall be incorporated onto the rear of faceplates and panels with unsupported spans of 10 inches or more or when the unsupported surface area exceeds 120 square inches.
- G. Nomenclature:
1. Nomenclature includes lettering, lines, borders, arrows, icons and other visual elements that are used to identity and organize device elements.
  2. Nomenclature shall be engraved directly into the surface, except where otherwise indicated on the detail Drawings.
  3. Engraved nomenclature shall be backfilled using enamel paint.
  4. Standard nomenclature colors:
    - a. Clear anodized faceplates and panels: Black .
    - b. Black anodized faceplates and panels: Yellow .
    - c. Clear stainless steel faceplates and panels: Black .
    - d. Standard colors identified above shall be furnished for faceplates and panels that are not otherwise detailed or scheduled to have different nomenclature colors.
- H. Devices:
1. General:
    - a. Where a connector type is not enumerated within this Section but is depicted on the Drawings or required by the system, the following manufacturers are approved for use:
      - 1) Neutrik.
      - 2) Switchcraft.
      - 3) Canare.
      - 4) AMP.
    - b. Where specific connector types are listed within this Section, only the listed model(s) are acceptable.
    - c. For consistency in appearance and performance, connectors of a given type shall be from a single manufacturer from a single series and the same model (where applicable).
  2. Default Connector Types:
    - a. Unless otherwise indicated on the Drawings, the following default connector types shall be provided for the usage indicated.
      - 1) Audio Signals:
        - a) Balanced audio outputs: XLR, 3-Pin Male.
        - b) Balanced audio inputs: XLR, 3-Pin Female.
        - c) Unbalanced mono audio inputs: 1/4-inch Phone tip-sleeve connector.
        - d) Unbalanced mono audio output: 1/4-inch Phone tip-sleeve connector.
        - e) Unbalanced stereo audio input pairs: (2) RCA phono connectors.
        - f) Unbalanced stereo audio output pairs: (2) RCA phono connectors.
        - g) Speaker level audio: speakON
      - 2) Data/Control Signals:
        - a) AMX Axlink: XLR, 4-Pin Female.
        - b) Crestron Cresnet: XLR, 4-Pin Female.
        - c) Ethernet: RJ-45, Category 6 rated Jack.



- d) Digital Audio (Dante, AVB): RJ-45, Category 6 rated Jack.
      - e) Serial RS-232: DB-9, Female.
      - f) Serial RS-422: DB-9, Female.
      - g) Serial RS-485 (without power): DB-9, Female.
      - h) Serial RS-485 (with power): XLR, 4-Pin Female.
    - 3) Digital Video:
      - a) HDMI: HDMI Female.
      - b) SDI, HD-SDI: Recessed BNC Bulkhead, Jack-to-Jack.
      - c) Proprietary UTP formats: Ethercon Category 6 Rated Jack.
  - b. Default connector types notwithstanding, the type of connector provided shall be subject to review during the submittal process and prior to the fabrication of any assembly. Review may uncover the need to depart from the default device type or gender.
3. Audio Connectors:
- a. XLR Type:
    - 1) Neutrik D-series (NC3FD and NC3MD).
    - 2) 3-Pins, unless otherwise detailed or noted.
    - 3) Nickel finish, unless otherwise noted.
    - 4) Use male gendered version for signal outputs.
    - 5) Use female gendered version for signal inputs.
  - b. 1/4-inch Tip-Sleeve (TS) and Tip-Ring-Sleeve (TRS) Type, Locking:
    - 1) Neutrik NC3FP6C.
  - c. 1/4-inch Phone Tip-Sleeve (TS) and Tip-Ring-Sleeve (TRS) Type:
    - 1) Switchcraft "Little-Jax" Series.
    - 2) Supply with accessory S1028 insulating flat washer and S1029 insulating shoulder washers.
  - d. 3.5mm Mini Phone Tip-Sleeve (TS) and Tip-Ring-Sleeve (TRS) Type:
    - 1) Switchcraft "Tini-Jax" Series.
    - 2) Supply with accessory insulating Switchcraft S1564 swedged fiber washer and S2207 insulating shoulder washer.
  - e. RCA – Phono, RCA Solderback:
    - 1) Canare RJ-R.
    - 2) Provide with accessory IU 7/16 insulating bushings/washers as follows:
      - a) Provide white insulators to designate "Left" audio channels.
      - b) Provide white insulators to designate "Mono" audio channels.
      - c) Provide red insulators to designate "Right" audio channels.
      - d) Provide black insulators to designate general purpose use.
  - f. RCA Phono:
    - 1) Switchcraft 3501FR.
    - 2) Solder based connections.
    - 3) Supply with accessory S1028 insulating flat washer and S1029 insulating shoulder washers.
      - a) Provide white insulators to designate "Left" audio channels.
      - b) Provide white insulators to designate "Mono" audio channels.
      - c) Provide red insulators to designate "Right" audio channels.
      - d) Provide black insulators to designate general purpose use.
  - g. speakON:
    - 1) 4-Conductor.
    - 2) 30A RMS continuous duty current rating.
    - 3) Twist-lock locking action.
    - 4) Indoor Applications
      - a) Chassis color: Black
      - b) Neutrik NL4MP
    - 5) Outdoor Applications

- a) Chassis color: Silver/Nickel
    - b) Neutrik NLT4MD
  - 4. Video Connectors:
    - a. BNC Recessed Bulkhead, Jack-to-Jack:
      - 1) Canare BCJ-JRU.
      - 2) Integral insulated-from-panel design.
    - b. BNC Non-Recessed Bulkhead, Jack-to-Jack:
      - 1) Canare BCJ-JR.
      - 2) Provide with accessory IU 7/16 insulating bushings/washers as follows:
        - a) Yellow for "composite" video signals.
        - b) Red, Green and Blue for component (Y-Pb-Pr) video signals.
        - c) Red, Green and Blue for RGsB video signals.
        - d) Red, Green and Blue, White for "RGBS" video signals.
        - e) Red, Green and Blue, White and Yellow for "RGBHV" video signals.
  - 5. Data/Control:
    - a. AMX Axlink or Crestron Cresnet:
      - 1) Neutrik D-series, NC4FD.
      - 2) 4-Pins, unless otherwise detailed or noted.
      - 3) Nickel finish, unless otherwise noted.
      - 4) Female gender for active buss connections.
    - b. Ethernet:
      - 1) Category 6 rated RJ-45 modular jack.
      - 2) Keystone form factor.

### **2.3 FACEPLATE GAP FILLERS**

- A. Gap fillers shall be supplied for installation behind faceplates to fill visible gaps that may result after installation.
- B. Thickness: 1/8-inch.
- C. Size: Height and width to exactly match the height and width of the faceplate, or 1/8-inch larger than the faceplate. Fillers of the oversized variety shall feature a bevel to ensure no exposed sharp edges on the assembly.
- D. Material: Anodized aluminum.
- E. Color and finish: To match the faceplate served.

### **2.4 MOUNTING HARDWARE**

- A. Phillips drive countersink oval-head machine screws shall be used to secure faceplates whose mounting-hole spacing is based upon the standard electrical device gang-box mounting hole spacing.
- B. Phillips-drive truss-head machine screws shall be used for securing faceplates and panels that are not sized to mount over a standard electrical gang box size.
- C. Rackmount based panels shall be secured to rack rails using truss-head type machine screws.

- D. Clear nylon washers shall be installed behind screw-heads not designed for countersinking. Washer thickness shall be 1 to 2 mm thick. The diameter of the washer shall match the diameter of the screw.
- E. Colors:
  - 1. Clear stainless steel and clear anodized aluminum faceplates and panels: Chrome.
  - 2. Black finish faceplates and panels: Matte or satin Black.
  - 3. Other faceplate colors: same as faceplate or panel color.

### **PART 3 - EXECUTION**

#### **3.1 COORDINATION**

- A. Coordinate pathway requirements with the Work of Section 270528 "Pathways for Communications."
  - 1. Coordinate the size of the back boxes and similar devices that are used for faceplate and panel mounting.
  - 2. Coordinate the set-back of boxes behind mounting surface to ensure the faceplate and panels shall be installed flush.
  - 3. Coordinate the proximity of adjacent back boxes to ensure adequate spacing remains for faceplate and panel installation without interference and to achieve an aesthetic alignment.
  - 4. Coordinate the entry-point of raceways into the boxes in such locations as to ensure cable radius minimums will not be violated.
- B. Coordinate the details of individual faceplates and panels with the Work of this Division.
- C. Coordinate labeling nomenclature between assemblies serving each system. Coordinate with the provider of the system(s) that will use them.

#### **3.2 FABRICATION**

- A. Faceplate and Panel Milling:
  - 1. Provide openings to accommodate devices to be mounted to a device-box prior to installation.
  - 2. Size openings in accordance with device manufacturer's recommended tolerances and in accordance with recognized industry standards.
  - 3. Mill the front and/or reverse side to accommodate mounting and attachment of devices sufficiently to achieve a professional appearance and allow the fully functional use of the devices without compromise.
- B. Device Mounting:
  - 1. Securely, neatly, and professionally attach devices.
  - 2. Mount devices so that they will not loosen during normal use and operation.
  - 3. Connector-type devices shall be secured so that they do not rotate when inserting, locking or removing mating devices.
  - 4. Switch-type devices shall be secured so that they do not rotate or work loose during operation.

5. Use mounting brackets and standoffs for mounting of devices where applicable. Use custom fabricated brackets and standoffs where standard brackets and standoffs are not readily available to suit the application.
6. Devices with through-mounting holes shall be secured using removable machine-threaded fasteners. Pop rivets shall not be acceptable.
  - a. Phillips drive flat-head countersink screws shall be used where the device manufacturer provides a countersunk mounting hole. The size of the head shall match the size of the countersink. Screw head shall not stand proud of the countersink and no sharp exposed edges of the screw shall exist.
  - b. Philips truss head machine screws shall be used for devices without countersunk mounting holes.
  - c. Thread-lock compound shall be applied to screw threads used to secure devices. Low-strength blue Loctite™ or equivalent shall be used.
7. Devices designed to be mounted without the use of through-mounting-holes shall be secured using the means expressly recommended by the device manufacturer.
8. Mount devices parallel to the dominant edge of the faceplate or panel.
9. Install devices so that there is no movement during use other than that which is intended by the manufacturer for the functional use of the device.

C. Assembly Wiring:

1. Wiring shall be neatly and professionally attached to devices and components. Employ strain relief techniques on pigtails to ensure no mechanical strain at the point of electrical connection.
2. Different color wires shall be used to aid in identification of circuits.
3. Legible permanent labels shall be attached to cables and conductors to aid in identification of purpose and circuit. Color codes and identification shall be accurately recorded on as-built documentation.

### 3.3 INSTALLATION

A. General:

1. Verify rough-in installation before device and faceplate installation:
  - a. Verify that wall boxes are installed plumb and level prior to installation of devices or the mounting of faceplates. Install within one-tenth (1/10) of a degree level and plumb.
  - b. Verify that the leading exposed edge of the rough-in does not stand proud of (i.e., protrude out beyond) the finished surface over which it is mounted.
  - c. If the rough-in is sufficiently out of tolerance as to prevent level, plumb and flush mounting of the faceplate, coordinate the rework of the rough-in with the responsible installer.
  - d. When these guidelines are disregarded, and faceplates are installed over rough-in that is out of level and not plumb, the cost to remove and reinstall a faceplate assembly is the responsibility of the faceplate assembly installer.
2. Ensure that each cable landing on a faceplate assembly is labeled and recorded on the as-built drawings prior to termination and mounting.

B. Mounting:

1. Install faceplates plumb and level. Drill and tap backboxes in the field as required.
2. Securely attach faceplates to approved box or sub-structure. Mounting to drywall, wood and masonry shall not be acceptable.
3. Install faceplates so they are flush with the surface behind (e.g., wall, ceiling, surface mount box, floor box).

4. Securely attach faceplates using machine threaded fasteners.

C. Gap Fillers:

1. Supply and install gap fillers behind faceplates to cover any resulting visible gaps between the rear faceplate surface and the surface over which it mounts.
2. Provide gap fillers that match the size of the faceplate. Provide custom-sized gap fillers where standard gap fillers are not available.
3. Where oversized gap fillers are permitted, install them so that a uniform reveal around the faceplate is achieved.
4. Adhere gap fillers to the rear of faceplate to ensure the filler remains correctly aligned when the faceplate is removed. Use of visible fasteners that exist for the sole purpose of affixing the gap filler shall not be acceptable.

D. Box Drilling and Tapping:

1. Faceplates that mount over SC-type or similar junction, pull and device boxes shall be mounted using machine-thread fasteners.
2. Mounting holes shall be drilled and tapped in the box, after the box has been installed, to match the level and plumb orientation of the faceplate or panel assembly. The holes shall be positioned so that the assembly is centered over the box. The holes shall be positioned such that the faceplate is plumb and level when secured.
3. Faceplate mounting holes shall be drilled and tapped in accordance with the Unified Thread Standard (UTS), using an appropriately selected UNC or UNF-class thread. The thread and tap-drill size used shall ensure that the box achieves two or more full threads at a minimum thread depth of 75%.

### **3.4 IDENTIFICATION**

- A. The specific nomenclature and graphics used on assemblies is subject to the review and modification by the Designer.

### **3.5 CLEANING**

A. Faceplates and Panels:

1. Clean and vacuum boxes prior to termination of cables to devices and again immediately prior to mounting.
2. Wipe down using cleaning products and methods recommended by the manufacturer.

B. Connectors:

1. Vacuum out connectors and clean the contacts of each.
2. Clear connector before use. Clean again after the connectors are subjected to environmental contamination.

### **3.6 PROTECTION**

- A. Protect products from physical damage during Work of the Project.
- B. Protect connectors from environmental contaminants during the construction period.

- C. Replace any product damaged during the course of the Project.

**END OF SECTION 27 1544**

**SECTION 27 1600****COMMUNICATIONS CORDS, DEVICES AND ADAPTERS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data.
  - 1. Bill of Materials (BOM).
  - 2. Product Datasheets.
- B. Closeout Submittals:
  - 1. Product Datasheets.
  - 2. As-Built Drawings:
    - a. Labeling Schema utilized for cable assemblies.
    - b. Cable color code utilized for patching.
  - 3. Cable and connectivity manufacturers' certification of quality and performance.
  - 4. Executed warranty documentation: Site specific; supplied from the manufacturer(s).
  - 5. Provide additional closeout documentation as required in Division 01 and Division 27 "General Requirements for Communications."

**1.2 REFERENCES**

- A. Definitions:
  - 1. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
  - 2. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
  - 3. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- B. Reference Standards:
  - 1. TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
  - 2. TIA/EIA-569-C, or most current version, Commercial Building Standard for Telecommunications Pathways and Spaces.
  - 3. TIA/EIA-606-B, or most current version, Administration Standard for Commercial Telecommunications Infrastructure.
  - 4. TIA/EIA-607-B, or most current version, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
  - 5. The most current published version of the "Telecommunications Distribution Methods Manual" published by the Building Industry Consulting Services International (BICSI).
  - 6. The most current published edition of the "Information Transport Systems Installation Methods Manual (ITSIMM)" published by the Building Industry Consulting Services International (BICSI).



**1.3 COORDINATION**

- A. Review and coordinate the quantity, lengths, colors and rating of patch cords with the Project requirements and the Owner prior to procurement and installation.

**1.4 QUALITY ASSURANCE**

- A. Prior to bid, Contractor shall be listed and shall maintain participation as part of the cabling and connectivity manufacturers' certified contractor programs. Provide documentation as outlined in Submittals.

**1.5 DELIVERY, STORAGE AND HANDLING**

- A. Store materials in conditions endorsed by the product manufacturer.
- B. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- C. Do not deliver or install product(s) in conditions that jeopardize the performance or manufacturer life expectancy and service life of the product.

**1.6 WARRANTY**

- A. Cabling and connectivity products manufacturers, including patch cords, shall have in place an agreement recognizing each other for complete execution of the warranty as specified. Performance and applications warranties shall be channel rated, including patch cables.
  - 1. Comply with warranty requirements of related Sections. The cable manufacturer and the connectivity products manufacturer shall have a partnership agreement established in order to provide the required warranty.

**1.7 SYSTEM DESCRIPTION**

- A. General:
  - 1. Provide cables, cords, devices and adapters as quantified and described.
    - a. Provide cable assemblies with electrical properties to match the designed infrastructure and specified in related Sections.
      - 1) 4 pair cable assemblies shall be TIA/EIA-568-C compliant to the Category specified for the 4-pair UTP horizontal cabling system.
      - 2) Cables may be color-coded by system.
  - 2. Provide adapters and devices as quantified and described.
    - a. Work shall comply with the Contract Documents and the manufacturers' printed recommended installation practices.
  - 3. System cables and device shall be UL/NEC rated for the location, manner, and environmental conditions in which the cables are installed.

4. Provide one single manufacturer for twisted-pair termination hardware and patch cable assemblies used together in a permanent link and whenever a Category Certification is required.
- B. Provide the following cable assemblies (cords), devices, and adapters:
  1. Patch Cables:
    - a. Length as required for the Equipment Room/Telecommunications Room end. Coordinate.
    - b. Confirm required cable color coding.
    - c. Provide rack patch cable in standard lengths selected to minimize “doubling” of the cable in wire management.
    - d. Labeled with the same unique identifier at both ends of the assembly.
    - e. Provide a quantity of one (1) for each horizontal cable installed.
      - 1) Includes provisions for voice/telephone, data/network, video surveillance, audio-visual, access control, control data and intrusion detection systems.
  2. Fiber Optic Patch Cable Assemblies:
    - a. Length as required for switch-to-switch and switch-to-patch panel connections. Coordinate.
    - b. Labeled with same unique identifier at both ends of the assembly.
    - c. Provide a quantity of one (1) pairs for each pair of backbone fiber optic cable strands installed.
      - 1) Includes provisions for, but not limited to, voice/telephone, data/network, wireless access point, video surveillance, audio-visual, access control, control data and intrusion detection systems.
  3. System cables shall be UL/NEC rated for the location, manner, and environmental conditions in which the cables are installed. Plenum rated patch cables shall be provided for above-ceiling applications.

## **PART 2 - PRODUCTS**

### **2.1 UTP PATCH CABLE ASSEMBLIES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Leviton Mfg. Company, Inc. (Leviton).
  2. Ortronics; a subsidiary of Legrand (Ortronics).
  3. Panduit Corp. (Panduit).
  4. CommScope, Inc. (CommScope).
  5. Hubbell Premise Wiring (Hubbell).
- B. Category 6A Copper Patch Cables:
  1. Comply with TIA/EIA-568-C, Category 6A.
  2. Independently tested and verified.
  3. UTP Cable Assemblies.
  4. Tested and verified to meet TIA component, permanent link and channel requirements.
  5. Confirm cable lengths with the Owner.
  6. Confirm cable color coding with the Owner.
  7. Basis of Design:
    - a. Panduit UTP6A#xx with labels added.

**2.2 FIBER OPTIC PATCH CABLE ASSEMBLIES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. CommScope, Inc. (CommScope)
  - 2. Hubbell Premise Wiring (Hubbell).
  - 3. Leviton Mfg. Company, Inc. (Leviton).
  - 4. Ortronics; a subsidiary of Legrand (Ortronics).
  - 5. Panduit Corp. (Panduit).
- B. Patch Cords: Factory-made, dual-fiber cables.
  - 1. Coordinate with the Owner for termination types to match equipment.
  - 2. Coordinate with the Owner and installed equipment locations for lengths required.
  - 3. Provide patch cords to match specified optical fiber performance.
  - 4. Provide quantities of patch cables required for switch-to-switch requirements.

**PART 3 - EXECUTION****3.1 GENERAL**

- A. Comply with TIA/EIA-568-C, including TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises; TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard; TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard; and TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.

**3.2 INSTALLATION OF CABLES**

- A. Maintain complete protection of cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades.
- B. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
- C. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSM, "Cabling Termination Practices" Chapter.

**3.3 IDENTIFICATION**

- A. Label each end of each cable, as described within this Section.
- B. Apply all labels straight and legible.

**END OF SECTION 27 1600**

**SECTION 27 2100****DATA COMMUNICATIONS EQUIPMENT****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Product Datasheets.
  - 2. Bill of Materials (BOM).
- B. Provide pre-installation wireless survey and wireless channel plan.
- C. Closeout Submittals:
  - 1. Product Datasheets.
  - 2. As-Built Drawings:
    - a. Rack Elevations.
    - b. Labeling Schema.
  - 3. Provide post-installation wireless survey.
  - 4. Field Quality Control / Test Results.
    - a. Report
      - 1) Type statement of compliance
        - a) Date tested
        - b) Technicians involved
        - c) Contact Information
        - d) Type of test performed
        - e) Captured test results
  - 5. Equipment inventories by site.
    - a. New Equipment
      - 1) Model Number
      - 2) Serial Number
      - 3) Manufacturer Name
      - 4) Location
        - a) Installed; specify where.
        - b) Date installed/ Date operational (turned over to Owner for use).
  - 6. Document configuration settings for all electronics and network management software.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Supply, installation and configuration network equipment consisting of and including but not limited to:
    - a. Router, Switches, Wireless Access Points and Fiber Transceivers
    - b. Provide patch cables, and all items required to connect system to cabling infrastructure.
    - c. UPS's
    - d. Provide unit prices for all equipment specified.
    - e. Perform a Pre and Post Install Wireless Survey

- f. Test all system components.
  - g. Include all equipment required for a complete and operational system.
  - h. Provide unit prices for all equipment specified.
- 2. System configuration as shown on the drawings and/or described in these specifications.

### **1.3 REFERENCES**

- A. Definitions:
  - 1. Layer x (1, 2, 3, 4, 5, 6, or 7); refers to the OSI model.

### **1.4 QUALITY ASSURANCE**

- A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate marking of applicable testing agency.
- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. The Prime Contractor or one of his subcontractors must have a Registered Communications Distribution Designer (RCDD) with Network Transport Systems specialty and/or Vendor specific qualifications such as a Cisco CCIE on staff who will act as Project Manager for the duration of the Project. The assigned Project Manager must have sufficient experience in this type of project as to be able to lend adequate technical support to the field forces during installation, during the warranty period, and during any extended warranty periods or maintenance contracts.
  - 1. Technical staff shall be local to the project site. Support services that must be obtained from more than 50 miles outside of the project site area are not considered compliant with these Specifications.
  - 2. A copy of the contractor's certifications (for the company and technical staff) and a resume of past projects for the company and staff must be attached to the Bid response for evaluation.
  - 3. The Contractor must offer a 24 hour per day, 7 day per week number that can be used to request emergency service or support during the warranty period.

### **1.5 WARRANTY**

- A. Additional requirements: Any modifications or equipment added to any existing system shall not void or alter any existing warranties held by the Owner.
- B. The Contractor must offer a 24 hour per day, 7 day per week number that can be used to request emergency service or support during the warranty period. Response to a call must be within 2 hours of initial request. Emergency service is defined as follows:
  - 1. Any WAN link inoperable
  - 2. Any backbone link inoperable
  - 3. Any switch inoperable
- C. Response time is defined as follows:
  - 1. Non-emergency service – 8 hours.
  - 2. Emergency service – 1 hour.

- D. Service / Maintenance Contracts (agreements).
1. Provide a limited lifetime replacement warranty on all switches.
  2. Provide tech support and 8 x 5 NBD hardware replacement maintenance program offered by the manufacturer of the Product.
  3. Maintenance agreements for ALL equipment must be coterminous beginning on final completion date.
  4. Provide the first year in the base contract to cover the initial warranty period; provide alternate price an additional year (alternate one on the response form).
  5. Provide additional hourly tech support rates for onsite and telephone support after initial warranty period. (This is to be provided by the Contractor, not the manufacturer.)

## **1.6 TRAINING**

- A. Provide Four (4) hours of training.
1. Review IP addressing scheme and other installation specifics.
  2. SNMP based management package and train Office staff on the proper use and capabilities.
- B. Trainer Qualifications:
1. Trainer must:
    - a. Have a thorough understanding of the electronics package provided.
    - b. Have a strong knowledge of IP addressing.

## **1.7 SYSTEM DESCRIPTION**

- A. Provide the following equipment and services:
1. Provide (supply, configure, and install) the local area network electronics as shown on the Drawings.
  2. Meet with owner or owner rep to determine all switch configuration requirements, including but not limited to IP addressing, VLAN's, QOS etc. prior to installation.
  3. Provide pre-installation wireless survey and wireless channel plan.
  4. Create a secure and safe log of addressing and password information for technology personnel.
  5. Remove all "back door" entrances into electronics set-ups and network information after completion of Project.
  6. This equipment will be managed by SNMP based network management software.
    - a. Configure to monitor alarms of the network electronics.
    - b. Minimum RMON capabilities include groups 1, 2, 3, and 9. Include RFC 1493 Bridge MIB and RFC 2674 802.1Q Bridge MIB.
  7. Supply all additional items required for a complete system.
    - a. Provide all GBIC interfaces as required to supply proper connectivity as shown on the network electronics diagram.
    - b. Provide required Category 6 data patch cables for all switch to switch connections.
      - 1) Connections through a pre-installed backbone between cabinets will require 2 patch cables per connection.
      - 2) Label as specified with the same unique identifier at each end of the cable.
      - 3) Utilize the same manufacturer for the cable assemblies as installed in the structured cable project to assure Category 6 compliance.
    - c. Provide Category 6 patch cables of 3 foot, 5 foot, or 7 foot lengths (as required for proper installation). Provide total quantity equal to the quantity of station ports supplied.

- 1) Coordinate with the Owner for color-coding of cable assemblies prior to purchase.
    - 2) Label as specified with the same unique identifier at each end of the cable.
    - 3) Utilize the same manufacturer for the cable assemblies as installed in the structured cable project to assure Category 6 compliance.
  - d. Provide necessary SC to SC or SC to MTRJ (or as required to interface with the electronics) fiber optic cable assemblies to complete all fiber optic connectivity.
    - 1) The optical properties shall be equal to the properties installed in the backbone as specified below.
  - e. Provide Category 6 station attachment cables of 10 foot lengths. Provide total quantity equal to the quantity of station ports supplied.
    - 1) Coordinate with the Owner for color-coding of station connectivity cable assemblies prior to purchase.
    - 2) Utilize the same manufacturer for the cable assemblies as installed in the structured cable project to assure Category 6 compliance.
  - f. Provide UPSs as shown on the drawings.
8. Test all equipment for proper operation.
  - a. Provide documentation in printed and electronic form as required in 1.8 above.
  - b. Provide post-installation wireless survey.
9. Comply with all additional provisions in this Specification. (Example: warranties, training, etc.)

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Products furnished of each Type shall be manufactured by a single manufacturer, bear the same brand name, be the same finish color and texture, and be from the same product model series, except where otherwise indicated.

### **2.2 PRODUCTS**

- A. Switches
  1. The following common features shall be provided for all switches
    - a. Fallback bridging of non-IP traffic
    - b. 802.3x flow control
    - c. 802.3p traffic prioritization
    - d. 802.3q VLAN tagging
    - e. SNMP and RMON management capabilities
    - f. Security features including User Authentication
    - g. Spanning tree protocol.
    - h. Automatic QoS (AutoQoS)
    - i. Dynamic Host Configuration Protocol (DHCP)
    - j. Auto-negotiation on all ports automatically selects half- or full-duplex transmission mode to optimize bandwidth.
    - k. Dynamic Trunking Protocol (DTP)
    - l. Port Aggregation Protocol (PAgP)
    - m. Link Aggregation Control Protocol (LACP)
    - n. Automatic media-dependent interface crossover (MDIX)
    - o. Unidirectional Link Detection Protocol (UDLD)
    - p. Local Proxy Address Resolution Protocol (ARP)



- q. Internet Group Management Protocol (IGMP) Snooping for IPv4 and IPv6 MLD v1 and v2 Snooping
  - r. Multicast VLAN Registration (MVR)
  - s. Auto Voice VLAN
  - t. VLAN Trunking Protocol (VTP) supports dynamic VLANs and dynamic trunk configuration across all switches.
  - u. Remote Switch Port Analyzer (RSPAN).
  - v. For enhanced traffic management, monitoring, and analysis, the Embedded Remote Monitoring (RMON) software agent supports four RMON groups (history, statistics, alarms, and events).
  - w. Layer 2 traceroute
  - x. Trivial File Transfer Protocol (TFTP)
  - y. Network Timing Protocol (NTP)
  - z. Must have a foot print of 1.75" or less.
  - aa. Must include mounting hardware for mounting on industry standard rack/cabinet rails.
- B. Standard GBIC Interfaces
- 1. 1000baseSX short wavelength SFP
    - a. Provide as Unit Cost
  - 2. 1000baseT UTP SFP
    - a. Provide as Unit Cost

### **PART 3 - EXECUTION**

#### **3.1 GENERAL**

- A. This Section is designed to provide the vendor with a standard of quality and functionality for the installation of the VoIP telephone system. Not all procedures may be necessary for the installation of this Project as well as not all necessary specific procedures are listed. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.
- B. Compliance
- 1. Comply with NECA 1.

#### **3.2 INSTALLATION**

- A. The Contractor is responsible for receiving, handling, storing, and protecting all materials utilized on this Project until the Project is signed as complete.
- B. Mount all rack/cabinet mounted electronics as per the rack/cabinet detail drawings.
- C. Contractor must clean up all scrap, materials, and tools to prevent the possibility of loss or injury. The Contractor must schedule work hours with the Construction Manager and/or maintenance staff of the building to determine time and length of shifts and weekend availability.

- D. This Contractor will install all necessary patch cables supplied for data patching; cables will be neatly installed in provided wire management panels. All length and color requirements will be coordinated with the Owner.
- E. Coordinate and configure subnetting per the Owner's request. Each subnet shall have no more than 200 addresses.
- F. The RIP 1 protocol will NOT be allowed. RIP 2 will be acceptable under written authorization from the Architect/Engineer. If RIP 2 routing is utilized, all switches must be configured with RIP 2 routing enabled.
- G. Wires and cables used in assembling racks or cabinets shall be formed into harnesses that are tied and supported for proper strain relief. Harnessed cables shall be combed straight. Each cable that breaks out from the harness for termination shall be provided an ample service loop and shall not violate the minimum bend radius of the cable.

### **3.3 INSTRUCTION**

- A. User training and setup:
  - 1. Select location(s) at the Project site approved by the Owner to conduct user- training classes as indicated.
  - 2. Provide user training as indicated.
  - 3. Provide necessary user manuals to all trainees.

### **3.4 TESTING AND DOCUMENTATION**

- A. Minimum test scenarios performed by the Contractor at each building site shall be as follows:
  - 1. From a testing console ping each server/services node for intra-building communications. Any unused ports shall be tested for proper operation and security parameters.
  - 2. Ping a node on each subnet on the entire network for inter-building communications. Any unused ports shall be tested for proper operation and security parameters.
  - 3. Contractor shall test each protocol for proper operation and routing.
  - 4. Contractor shall test all redundant hardware for proper operation and timing recovery.
  - 5. Contractor shall test all security policies on services devices, and sub-nets for proper operation. It shall be the Contractor's responsibility to coordinate with the Owner to ensure all security policies are installed per the Owner's requirements.
  - 6. Each test shall be observed and recorded either by using third party software or on a manual record.
  - 7. All records shall be submitted the Owner/Consultant for review.
- B. The Owner reserves the right to have a representative present during testing procedures. Verification testing of copper and fiber may be performed at or near Project completion by the Consultant for quality assurance.

**END OF SECTION 27 2100**

**SECTION 27 4100****AUDIO AND VIDEO SYSTEMS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials (BOM).
    - a. Separate list for each system.
  - 2. Product Datasheets.
- B. Shop Drawings:
  - 1. System diagrams.
  - 2. Rack elevations.
  - 3. Floor plans.
- C. Closeout Submittals:
  - 1. As-built drawings.
  - 2. Programmable-product configuration file(s):
    - a. Source code version of files necessary for changes to be made by qualified personnel.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Supply, installation and integration of complete and working audio and video systems.
- B. Products installed but not supplied as work of this section:
  - 1. Equipment racks.
  - 2. Local power distribution products.
- C. Related Requirements:
  - 1. Related Sections:
    - a. Section 271116 "Cabinets, Racks, Frames and Enclosures" for racks and accessories.
    - b. Section 271126 - Rack Mounted Power Protection and Power Strips for power distribution products.
    - c. Section 271544 "Custom Faceplates, Panels and Connectors" for custom fabricated faceplate assemblies.
    - d. Section 274101 "Audio and Video Systems Cabling" for cable and connectors used to interconnect AV system equipment.
    - e. Section 274103 "Audio and Video Systems Software Development" for custom software development guidelines.

**1.3 QUALITY ASSURANCE**

- A. Comply with Section 270002 "Quality Assurance for Communications."

**1.4 WARRANTY**

- A. Comply with Section 270001 "General Requirements for Communications."
- B. The warranty period for individual systems shall not start until the system is complete and working for its intended purpose
- C. Poor execution of Work can lead to warranty obligations that extend beyond the termination date of the manufacturer's warranty.

**1.5 SYSTEM DESCRIPTION(S)**

- A. See technology drawings for system description(s).

**PART 2 - PRODUCTS****2.1 GENERAL**

- A. The Contract Documents, including specifications in conjunction with the drawings, shall be used together to conclude the project requirements.

**2.2 SUBSTITUTIONS**

- A. Brands and models listed on the drawings represent the Basis-of-Design and standard of quality for the identified components. The use of any product other than a Basis-of-Design product in this Section is considered a substitution. These products must include the feature set and operational characteristics to achieve the design intent.
- B. Substitutions are not permitted.

**2.3 EQUIPMENT**

- A. System equipment shall be derived from the system diagrams. Provide all products necessary for a complete and working system including those not expressly identified on the documents.
- B. Products depicted on the drawings which are not identified by brand and model are the responsibility of the Contractor to furnish and install. The decision whether a Contractor selected product is acceptable remains with the Designer.
- C. Supply manufacturer recommended accessories where necessary.

**2.4 MISCELLANEOUS**

- A. Audio combining and balancing components:
  - 1. Manufacturers: Subject to compliance with requirements, provide products manufactured by the following:
    - a. Extron
    - b. Jenson.
    - c. Op-Amp Labs.
    - d. RDL
    - e. Whirlwind.
- B. Custom Rack shelves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products manufactured by the following:
    - a. Middle Atlantic.
    - b. Lowell Manufacturing.
    - c. Raxxess.
  - 2. Basis-of-Design: Middle Atlantic RSH series.

**PART 3 - EXECUTION****3.1 INSTALLATION**

- A. Safety:
  - 1. Install products in such manner as to protect life and property.
  - 2. Furnish and install safety accessories recommended by the manufacturer.
- B. Grounding:
  - 1. Implement signal and safety grounding and bonding to ensure the safety and performance of the system, its operators and the facility in which it is located.
- C. Impedance and Level Matching:
  - 1. Provide impedance matching devices at points in the system where such devices are technically necessary to achieve proper gain staging, product and system performance.
  - 2. Provide passive isolation to eliminate ground loops between equipment.
- D. Audio Combining and Balancing:
  - 1. Where audio signal distance exceeds 15', a balanced signal must be used.
- E. Speakers:
  - 1. Calculate loudspeaker aiming with the objective of achieving the most uniform direct-sound coverage that is possible in the target areas.
  - 2. Install speakers (other than ceiling-type speakers) using steel cable, wire rope, chain or rigid but field adjustable mounts that enable aiming of the speakers into the target coverage areas.
  - 3. Speakers destined for installation in suspended ceilings shall be installed using an accessory tile bridge that spans tiles and supports the speaker from the metal ceiling grid system. For secondary support, an accessory safety cable shall be provided to support the speaker from the structure.

4. Install speakers in a secure manner to sound building structures capable of safely sustaining the load applied to it..
  5. Install speakers using materials and mounting methods that ensure that neither the speaker nor the mounting system emits extraneous audible noise when the speakers operate within design limits.
  6. Paint exposed mounting brackets, supports and hardware to match surrounding finish.
- F. Equipment Racks, Cabinets, Enclosures and Furniture:
1. Provide vertical and horizontal wire management products to secure and manage cables.
  2. Provide horizontal wire support bars. Secure bars in such locations as to achieve a professional balance between cable support, equipment accessibility, service and appearance.
  3. Install service loops. Service loop length shall be determined as follows:
    - a. Long enough that the cable can be relocated to a variety of other compatible ports on the product, sufficient to enable the cable to be landed on a different port if it is incorrectly landed.
    - b. Long enough that it can be moved aside without becoming unplugged, being damaged or stressed while attempting to access another nearby connection.
    - c. Long enough that no stress is applied to the cable itself, a conductor, any other cable, or connectors on the equipment.
    - d. Short enough not to hinder serviceability of an adjacent product.
  4. Power Distribution:
    - a. Install power distribution products to serve system equipment.
    - b. Install not less than 20 percent usable spare outlets that are free, clear, and available for future use.
  5. Install filler panels for unoccupied spaces. Provide a mixture of vent and blank type panels that enable manufacturer requisite airflow over equipment for cooling.
  6. Bundle cables carrying different signal formats and levels separately into independent bundles. Separate bundles with an air space sufficient to prevent interference that adversely affects performance.
- G. Connection Plates/Panels:
1. Comply with Section 271544 "Custom Faceplates, Panels and Connectors."
  2. In addition to locations identified on the drawings, provide connection plates/panels:
    - a. At wall, floor and ceiling equipment locations that accommodate interconnection of portable or movable equipment.
    - b. At video display equipment locations.
    - c. At surface mount devices that are not installed with a direct pathway connection.
    - d. At wall, floor, and ceiling boxes where the cable terminates in a piece of equipment that does not mount in/over the box.
  3. Provide custom manufactured plates/panels when pre-manufactured standard plates/panels are not explicitly specified.
- H. Mounting and Support:
1. Provide professionally engineered and professionally manufactured mounts and supports for non-portable products.
  2. Provide final engineering mounting products.
  3. Utilize the services of a registered Professional Engineer (PE) to certify custom mount designs and mounting methods of products whose weight does not fully rest on the floor.
  4. Follow the recommendations of the manufacturer for installation of pre-engineered non-custom mounting assemblies. Consult and follow the recommendations of a mechanical Professional Engineer (PE) in those cases where the manufacturer does not publish specific recommendations for product installation for a specific application.

5. Except where code or the Contract Documents require a higher rating, a minimum safety factor of (5) shall apply to the structural integrity of product mounting methods.
6. Submit shop drawings of custom mounting assemblies and atypical installation of pre-manufactured mounts prior to fabrication or installation. Designer's review and related comment(s) shall be limited to matters of function and appearance.
7. Designer reserves the right to reject any mount and mounting methodology that is not submitted for review prior to installation or that is submitted for review but contains exposed elements that do not satisfy the architectural and aesthetic objectives of the Project.

**I. Projector Lifts:**

1. Prior to procurement of lifts:
  - a. Review existing and planned construction to verify that the lift can be successfully installed in the target location.
  - b. Verify that the lift assembly dimensions fully accommodate the successful installation of the intended projector(s), mount(s) and the ancillary electronics that are co-located with the projector(s). Review shall include verification of cable, connector and lens clearance.
2. Coordinate the location of lifts with the requirements of the projectors that will be housed within the lift. Consult the Designer should any deviations from the drawings become necessary.
3. Proactively review and coordinate the locations of lifts with other trades providing work in the vicinity of the lifts.
4. Follow the lift manufacturer's recommendations for installation. Seek the direction of the Designer should there be a conflict between the Contract Documents and the Manufacturer's installation recommendations.
5. Do not drill any holes in building structural members without prior authorization of the Project's structural engineer.
6. Install lifts level and square to building lines and flush and square to finished ceilings, except where alternate direction from the Designer is expressly noted.
7. Coordinate and connect power to the lift.
8. Install lifts and perform manufacturer recommended adjustments prior to installation.
- 9.
10. Program the lift and its associated projector(s) in such a manner as to prohibit the projector lift from closing until the projector is off and its lamp has cooled.
11. Exercise extreme care to protect surrounding ceilings, most notably in retrofit installations. Remove, replace, repair and restore any ceiling, wall, or floor that is negatively affected by installation, service or adjustment.
12. Protect cables from wear and damage during lift operations.
13. Dress cables for a neat appearance. Install bundles of two or more cables within flexible sleeving to achieve a clean appearance.

**J. Projection Screens:**

1. Prior to procurement of screens:
  - a. Verify that the size and position of the viewing surface is coordinated to complement the projector, lens and lift. Seek clarification from the Designer if there are any questions concerning size, aspect ratio, or image positions.
  - b. Confirm the amount of extra "drop" required above the intended image area, and procure screens only after confirming the amount of extra drop required.
2. Prior to installation verify that projectors, lens and screens will not be adversely affected by any obstacle that may cast a shadow upon the screen. Coordinate adjustments in positions as necessary to ensure obstruction free operation.
- 3.
4. Install screens level and perpendicular to projection optics.



5. Furnish and install manufacturer's low voltage controllers for motorized screens.
  6. Furnish and install manufacturer's wall mounted control panels for motorized screens.
  7. Proactively coordinate the installation of screens with work of other trades early in the Project to ensure that space remains free and clear for the unobstructed installation and operation of the screen.
  8. Provide support blocking and/or metal support structure for support of screens.
  9. Adjust screens according to manufacturer's instructions and recommendations:
    - a. Set tension of tab-tensioned screens after the screens are in their "show" position.
    - b. Set limit switches to ensure that the screen travels to its target "show" position(s).
    - c. Set additional preset limit positions.
  10. Exercise extreme care to protect surrounding ceilings during installation. Remove, replace, repair and restore any ceiling, wall, or floor that is negatively affected by installation, service or adjustment.
  11. Clean screen surfaces prior to acceptance. Follow screen manufacturer recommendations for cleaning.
- K. Video Projectors:
1. Seek the direction of the Designer if any issues arise that adversely affect the installation of projector(s) at the designated location(s).
  2. Provide manufacturer recommended lens for each projector.
  3. Procure lens after verification that the lens is compatible with the projector and target image conditions. Seek the direction of the Designer if any deviation from an explicitly specified lens is believed necessary.
  4. Provide an adjustable support system for each ceiling mounted projector. The support systems shall permit front-to-back and side-to-side positioning of the projector.
  5. Install support system in a trapeze fashion where necessary to work around obstacles. Brace suspended elements to prevent horizontal movement.
  6. Prior to installation of the support structure, verify that the target location is currently, and is planned to remain free and clear of obstacles that may adversely affect installation or the performance of the projection system. Coordinate with other trades to remediate conflicts.
  7. Proactively coordinate the location of power receptacle(s) to ensure they are initially located near the projector in a position that affords minimal power cord length.
  8. Install projectors so that their weight is carried by building structure and not from non-structural building components such as drywall, ceiling tiles and ceiling grid.
  9. Provide projector mounts that are adjustable and that can be locked down rigidly. Lock down after final alignment.
  10. Perform projector manufacturer recommended post-installation adjustments, including, but not limited to, zoom, focus, aspect ratio, convergence, focus, clock and phase.
  11. Color match projectors whose images are displayed side-by-side.
  12. Make adjustments that render the projectors usable for their intended purpose as an integral part of the complete system.
  13. **Exercise care to protect surrounding ceilings. Remove, replace, repair and restore any ceiling, wall, or floor that is negatively affected by installation, service or adjustment.**
- L. Portable equipment and accessories:
1. Install batteries in products that require battery power, including remote controls.
  2. Install a label on each remote identifying the component.
- M. Lighting:
1. Provide physical interface and cabling to the lighting system(s). Coordinate with the lighting system products provider and equipment manufacturers to obtain control protocols.

**N. Rack Mounts:**

1. Provide rack mounts for securing products within equipment racks. Standard rack shelves are not permitted, except where expressly depicted on the drawings and/or otherwise authorized by the Designer.
2. Provide accessory rack mounts from the product manufacturer, where available.
3. Provide custom rack mounts from an approved manufacturer when the product manufacturer does not offer an accessory rack mount.

**3.2 IDENTIFICATION**

- A. Comply with Section 270553 "Identification for Communications."
- B. Label each system product.

**3.3 SOFTWARE DEVELOPMENT**

- A. Comply with Section 274103 "Audio and Video Systems Software Development."

**3.4 ADJUSTING****A. General:**

1. Upon completion of physical installation, each system shall be adjusted. Adjustments shall be as necessary to make the system usable for its intended purpose and to the satisfaction of the owner's representative and designer.
2. Adjustments shall be performed as recommended by each product manufacturer, recommended as a best practice by a referenced standard or a recognized related trade organization, and where additionally directed by the Designer.
3. Products featuring analog controls shall be marked with self-adhesive dots or arrows to indicate their final settings.

**B. Adjustments:**

1. Audio Subsystems:
  - a. Gain staging:
    - 1) Adjust equipment to achieve optimum signal-to-noise ratio and lowest possible distortion. Optimum settings will generally be achieved when points in the signal chain reach maximum level / clipping / distortion at the same time.
    - 2) Adjust input trim gain and pads on mixers.
    - 3) Adjust the gain of both analog and digital products.
    - 4) Record settings for future reference.
  - b. Loudspeaker Aiming:
    - 1) Fine-tune the aiming of loudspeaker components to achieve coverage uniformity within the target coverage areas while simultaneously minimizing sound energy directed towards walls, ceilings, and other areas not intended as listening areas.
    - 2) Fine tune physical positioning of components to achieve minimum phase interaction, prior to implementing the use of any form of electronic phase or delay adjustments.
  - c. Frequency crossovers and filters:

- 1) Adjust crossovers for minimum interaction between components throughout the crossover frequency region.
- 2) Set crossover frequencies and filters according to recommendations of the loudspeaker manufacturers.
- 3) Adjust crossover delays for maximum coherency and minimal acoustic comb-filtering.
- 4) Record settings for future reference.
- d. Equalize individual speakers:
  - 1) Adjust loudspeaker filters. This process shall result in the flattening of the frequency response of individual speakers or adjustment to a specific frequency response contour.
  - 2) Equalize speakers using band-pass filters in conjunction with parametric equalization in lieu of fixed-Q graphic equalization.
  - 3) Use subtractive (cut) rather than additive (boost) techniques for achieving target frequency response contours.
  - 4) Derive settings for speakers from loudspeaker manufacturers or using independent TEF™ analysis performed by a trained audio engineer.
  - 5) Record the final settings for future reference. Lock down equipment settings to prevent accidental changes where such capability exists.
- e. Equalize the complete electro-acoustic system:
  - 1) Adjust filters that serve the entire electro-acoustic system to achieve the target frequency contour. Where system equipment capability allows, use separate filter sets upstream from the individual loudspeaker filters.
  - 2) Adjust filters to achieve tonal balance between areas covered by different models of loudspeakers.
  - 3) Adjust filters to achieve a balance between gain before feedback performance and tonality.
  - 4) Contact the Designer for target equalization curves prior to performing system equalization.
  - 5) Record settings for future reference.
- f. Audio delays:
  - 1) Adjust delays that serve loudspeakers that are physically separated.
  - 2) Adjust delays to achieve aural localization with maximum achievable HASS Integration.
  - 3) If the space served is a multi-function space and the area of focus changes to suit different event types, establish separate recallable delay and level configurations for each configuration.
  - 4) Record settings for future reference.
- g. Voltage and power limits:
  - 1) Adjust settings that allow the system to reach but not exceed maximum sound pressure level maximums established by the Designer or Owner.
  - 2) Adjust settings that limit the voltage and power delivered to loudspeakers to within the safe operating range as published by each individual loudspeaker manufacturer. These settings are generally independent of settings used to limit sound pressure levels.
  - 3) Lock down, cover, and protect these settings from unauthorized change.
  - 4) Record settings for future reference.
- h. Miscellaneous:
  - 1) Adjust manual and automatic audio mixers. Review and adjust settings available on the product; adjust to achieve performance that is acceptable to the Designer.
  - 2) Enable phantom power on inputs that are intended to accommodate direct connection of condenser microphones and disable phantom power on those

- inputs that are not intended to accommodate direct connection of condenser microphones.
- 3) Adjust automatic gain controllers (AGC).
- 4) Adjust expanders.
- 5) Adjust compressors.
- 6) Adjust limiters.
- 7) Adjust noise gates.
- 8) Adjust ambient level sensing.
- 9) Adjust signal-processing equipment.
- 10) Record settings for future reference.
- i. Audio Video Synchronization:
  - 1) Adjust signal delays to achieve synchronization between associated audio and video signals.
- 2. Video Subsystems:
  - a. Display Equipment:
    - 1) Adjust video display equipment following the guidelines set forth by the display equipment manufacturer.
    - 2) Adjust image size and position.
    - 3) Adjust color temperature and color settings.
    - 4) Color match display images that appear side-by-side.
    - 5) Adjust image brightness and contrast.
    - 6) Adjust limit switches on mechanized screens.
    - 7) Store settings for manual and automatic recall to satisfy operational requirements.
    - 8) Record settings for future reference.
  - b. Signal processing:
    - 1) Configure and store multi-image view settings.
    - 2) Adjust and store image scaling settings.
    - 3) Record settings for future reference.
  - c. Convergence:
    - 1) Adjust video transmission products in accordance with each individual manufacturer's instructions so that individual colors are aligned at the output of links.
  - d. Timing:
    - 1) Adjust video timing in systems that include video conferencing, broadcast, video production and recording capability.
  - e. Camera:
    - 1) Adjust cameras following the procedures recommended by the camera manufacturer.
    - 2) Adjust cameras so that they each produce the same quality and appearance of image.
    - 3) Adjust and store presets (pan, tilt, zoom and focus) for memory locations supported by the camera.
    - 4) Adjust and store separate presets in control system memory for each mode of system operation.
- 3. Control Subsystems:
  - a. Adjust the communication speed between controlled products. Use the fastest speed available that results in consistent reliable communications.
- 4. Lighting Subsystems:
  - a. Participate in the adjustment of the lighting system(s) that serve the spaces containing systems provided as Work of this Section.
  - b. Assist the lighting system provider through proactive coordination and supply of guiding input on the following:

- 1) Aiming and cropping of fixtures that impact usability of the system. This includes but is not limited to fixtures that serve the stage or other presenter areas and areas that rely on specific lighting for highest quality camera performance. Special attention shall be given towards achieving presenter areas that are well lit for both on- and off-camera uses while achieving maximum contrast on video display screens.
- 2) Establishment of usable lighting scenes that complement the configurations of the space and modes of system operation.

### **3.5 TESTING**

- A. General:
  1. Tests shall be performed on the system to the degree necessary to confirm that the system is fully usable to the Owner for its intended purpose to the satisfaction of the Designer.
  2. Tests shall be performed to confirm that the products are performing according to manufacturers' specifications.
- B. Speaker Line Impedance Verification:
  1. Prior to landing speaker circuits onto amplifiers, measure and record the impedance of each individual speaker circuit. Confirm that the measured impedance coincides with the calculated impedance conditions and that they are within the safe operating range of the amplifier used.
- C. Sound Level Uniformity:
  1. Conduct sound pressure level measurements to confirm that coverage is uniform throughout the target listener areas.

### **3.6 REMEDIAL ACTIONS**

- A. Replace defective products, re-terminate defective connections, perform re-adjustments and re-test offending elements of the system should any deficiencies be found during execution of the Work.

### **3.7 TRAINING**

- A. Provide training for each unique system.
- B. Train Owner designated end-user staff.
  1. Include hands-on demonstrations covering typical uses of the system in day-to-day operation.
  2. Include hands-on demonstration on how to change the modes of the system.
  3. Include training covering how to set up and use the system for each type of event.
  4. Include training on how to perform actions/operations available on the system user interfaces intended for end-user staff.
- C. Training Owner designated maintenance staff.
  1. Include same training as support staff and facilitators.
  2. Include training on preventative and routine maintenance measures that are important to long-term reliability and operation of the system.

- D. Training shall include techniques for making level adjustments, using and placing microphones, and operating individual pieces of equipment.
- E. Training shall include hands-on demonstrations based upon Owner projected real-world system use scenarios.
- F. Enlist and provide the services of manufacturer personnel or qualified third party personnel to conduct training on major system components on which the Contractor is not proficient.
- G. Provide (120) hours of system specific training.
  - 1. Provide 30 percent of training prior to the first official use of the system.
  - 2. Provide 20 percent of the training after 15 days of system use.
  - 3. Provide 20 percent of the training after 30 days of system use.
  - 4. Provide 20 percent of the training after 90 days of system use.
  - 5. Provide 10 percent of the training after 180 days of system use.
- H. Training that occurs prior to final system completion does not count towards the required training allowance unless training approval is requested of and granted by the Designer in advance of the training taking place.
- I. A sign-in sheet shall be used to record the signatures of persons attending each training session. The sign-in sheet shall include the start and end times of the session and shall have attached to it a copy of the associated training handouts. Only well documented training sessions apply towards the required training.

### **3.8 PROTECTION**

- A. Protect products from damage and from environmental conditions and contaminants that could adversely affect performance, reliability, manufacturers' warranty or longevity.
- B. If physical protection must be removed for continuation of Work, protection shall be removed only for the duration and extent necessary. Product shall be cleaned prior to reinstallation of protection.

### **3.9 CLEANING**

- A. Clean each system product after installation, immediately prior to substantial completion, and at additional times during performance of Work as recommended by the product manufacturer.
- B. Clean the interior of system racks, enclosures and furniture.
- C. At the start of the warranty period, system equipment shall feature manufacturer factory-fresh appearance.

**3.10 SPECIAL SUPPORT REQUIREMENTS**

- A. For the first 6 uses of the system after substantial completion, provide support personnel to assist the Owner with set up and operation of the system(s). Personnel shall:
  - 1. Arrive before the event.
  - 2. Remain for the duration of the event.
  - 3. Assist with system setup, operation and teardown.
- B. If the system(s) are not substantially complete, or if training has not been provided prior to the scheduled completion date(s), provide qualified personnel to setup and operate the associated systems in lieu of the Owner.
- C. Support personnel shall be familiar with the system equipment and shall be qualified to provide the appropriate support for the event.

**END OF SECTION 27 4100**



**SECTION 27 4101****AUDIO AND VIDEO SYSTEMS CABLING****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Product Data:
  - 1. Bill of Materials
    - a. Separate list for each system.
    - b. List to identify the signal format the cable will be used to transport.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Cables for the interconnection of audio and video equipment, and related control system products.
  - 2. Standards-of-practice by which products are to be installed and tested.
- B. Related requirements:
  - 1.
  - 2. Section 271323 "Fiber Optic Backbone Cabling" for intra-building fiber optic backbone cabling and termination hardware, including channel rated performance and applications warranty.
  - 3. Section 271513 "Copper Horizontal Cabling" for intra-building, four-pair twisted pair cabling and patch panel termination hardware, including channel rated performance and applications warranty.
  - 4. Section 274100 "Audio and Video Systems."

**1.3 DEFINITIONS**

- A. DVI: Digital Video Interface.
- B. HDMI: High Definition Media Interface.
- C. HDSDI: High Definition Serial Digital Interface.

**1.4 QUALITY ASSURANCE**

- A. Comply with Section 270002 "Quality Assurance for Communications."

**PART 2 - PRODUCTS****2.1 GENERAL**

- A. Refer to the related drawings and specifications to determine the quantity, quality, and performance of products to be furnished. The cables provided as work of this section are fully dependent upon them.
- B. Consult with the manufacturers of the equipment to be interconnected to further determine the quantity, quality, and performance of cable required.
- C. Where the manufacturer of the product being interconnected requires cable featuring more stringent requirements than those identified in this Section, provide cable meeting the more stringent requirements.
- D. Brands and models listed represent the Basis-of-Design and standard of quality for the identified cables. The use of any product other than a Basis-of-Design product in this Section is considered a substitution. These products must include the operational characteristics equal to or greater than the Basis-of-Design.

**2.2 FIXED INSTALLATION CABLES**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following manufacturers:
  - 1. Belden
  - 2. Canare Cable.
  - 3. Crestron.
  - 4. Extron
  - 5. Liberty Wire and Cable.
  - 6. West Penn Wire.
  - 7. Windy City Wire
- B. General Requirements:
  - 1. Fixed installation cables shall be UL Listed and NEC type acceptable for the location, application and manner of installation.
  - 2. Cables shall meet NEC 300 volt rating, higher where otherwise specified.
  - 3. Cable supplied to satisfy the requirements of a specified cable type shall be as manufactured from a single manufacture except as otherwise approved by the Designer (e.g. all RG-6 non-plenum analog video cable shall be from single manufacturer).
  - 4. Within a building, cables that are not installed in a totally enclosed pathway system shall be UL plenum rated.
  - 5. Cables used for below grade applications, in-grade floor boxes, and cables used in pathways that may reasonably end up with standing water within them, shall be manufacturer rated for continuous contact with water without performance degradation or compromise in warranty.
- C. Video:
  - 1. 12G-SDI:
    - a. 12 Ghz Rated.

- b. RG-6/U type coaxial unit.
  - c. Shields: 100% aluminum polyester tape, covered with 95% tinned copper braid.
  - d. Overall diameter:  $\leq .320$  inches.
  - e. Coax center conductor size: 16 AWG.
  - f. Coax conductor material: Silver plated copper.
  - g. Coax dielectric: High-density polyethylene insulation.
  - h. DC Resistance - Conductor:  $\leq 4.0$  ohms per 1000 feet.
  - i. DC Resistance - Shield:  $\leq 1.9$  ohms per 1000 feet.
  - j. Capacitance:  $\leq 15.0$  pF/ft.
  - k. Nominal velocity of propagation:  $\geq 85\%$ . Nominal Impedance: 75 ohms.
  - l. Colors: Available from manufacturer in 5 standard colors.
  - m. Basis-of-Design: Belden 4794R.
- 2. HD-SDI:
  - a. 6 Ghz Rated.
  - b. RG-6/U type coaxial unit.
  - c. Shields: 100% aluminum polyester tape, covered with 95% tinned copper braid.
  - d. Overall diameter:  $\leq .229$  inches.
  - e. Coax center conductor size: 18 AWG.
  - f. Coax conductor material: Bare solid copper.
  - g. Coax dielectric: Foam Fluorinated Ethylene Propylene.
  - h. DC Resistance - Conductor:  $\leq 6.4$  ohms per 1000 feet.
  - i. DC Resistance - Shield:  $\leq 2.8$  ohms per 1000 feet.
  - j. Capacitance:  $\leq 16.1$  pF/ft.
  - k. Nominal velocity of propagation:  $\geq 82\%$ .
  - l. Nominal Impedance: 75 ohms.
  - m. Colors: Available from manufacturer in 5 standard colors.
  - n. Available in UL Listed plenum and riser versions.
  - o. Basis-of-Design: Belden 1695A.
- 3. HDMI:
  - a. HDMI version 2.0 or greater.
  - b. Resolution and Refresh Rate:  $\geq 4096 \times 2160$  @ 60 Hz.
  - c. Chroma Sampling: 4:4:4.
  - d. Bit Depth per Color:  $\geq 8$  bit.
  - e. Data Rate: 18.0 Gbps.
  - f. Basis-of-Design:
    - 1) Length less than or equal to 12 feet: Extron HDMI Ultra series.
    - 2) Length greater than 12 feet: Extron HDMI Pro series.
- 4. DisplayPort:
  - a. DisplayPort version 1.4 or greater.
  - b. Resolution and Refresh Rate:  $\geq 4096 \times 2160$  @ 60 Hz.
  - c. Chroma Sampling: 4:4:4.
  - d. Bit Depth per Color:  $\geq 8$  bit.
  - e. Data Rate: 21.6 Gbps.
  - f. Basis-of-Design: Extron DisplayPort Ultra series.
- 5. USB:
  - a. USB 3.0 Compliant
  - b. Data Rate: 4.8 Gbps
  - c. Basis-of-Design: Liberty E-USB3 series.

**D. Twisted Pair Cable**

1. Furnish cable compliant with Section 271513 "Copper Horizontal Cabling"
  2. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Manufacturers listed in 271513 "Copper Horizontal Cabling".
    - b. Crestron
    - c. Extron
  3. General:
    - a. General Performance: Comply with transmission standards in TIA/EIA-568-C when tested according to test procedures of this standard.
      - 1) Twisted pair cable is required to have the appropriate Category classification as defined by TIA/EIA-568-C. Compliance with these electrical characteristics shall be third party verified by the manufacturer.
    - b. Where applicable, provide the manufacturer recommended cable for the products being interconnected.
    - c. Basis-of-Design: Belden 2183P.
- E. Audio, Speaker Level:
1. General:
    - a. Where wire gauge is not specified on the drawings, calculate based on the following requirements:
      - 1) Line loss shall not exceed 2.00 dB.
      - 2) Equation used to calculate the data:  

$$Ploss = 10 * \log (1 - ((2 * RL) / (2 * RL + (Vline squared / Prated))))$$

$$RL = (Rref / 1000) * D$$

Where:  
 D = length of wire used  
 Ploss = power loss in dB  
 Prated = power driven on line  
 RL = wire gauge resistance  
 Vline = voltage on line
  2. 10-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 10AWG (x 2), bare copper, stranded.
    - c. Nominal diameter:  $\leq .302$  inches.
    - d. DCR @ 20 deg C: 1.07 Ohms/1000 feet.
    - e. Capacitance:  $\leq 28$  pF/ft.
    - f. Basis-of-Design: Belden 6T00UP.
  3. 12-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 12AWG (x 2), bare copper, stranded.
    - c. Nominal diameter:  $\leq .252$  inches.
    - d. DCR @ 20 deg C:  $\leq 1.6$  Ohms/1000 feet.
    - e. Capacitance:  $\leq 36.0$  pF/ft.
    - f. Basis-of-Design: Belden 6000UE.
  4. 14-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 14AWG (x 2), bare copper, stranded.
    - c. Nominal diameter:  $\leq .210$  inches.
    - d. DCR @ 20 deg C:  $\leq 2.53$  Ohms/1000 feet.
    - e. Capacitance:  $\leq 36.0$  pF/ft.
    - f. Basis-of-Design: Belden 6100UE.

5. 16-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 16AWG (x 2), bare copper, stranded.
    - c. Nominal diameter:  $\leq .176$  inches.
    - d. DCR @ 20 deg C:  $\leq 3.8$  Ohms/1000 feet.
    - e. Capacitance:  $\leq 36.5$  pF/ft.
    - f. Basis-of-Design: Belden 6200UE.
  6. 18-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 18AWG (x 2), bare copper, stranded.
    - c. Nominal diameter:  $\leq .154$  inches.
    - d. DCR @ 20 deg C:  $\leq 6.5$  Ohms/1000 feet.
    - e. Capacitance:  $\leq 34$  pF/ft.
    - f. Basis-of-Design: Belden 6300UE.
- F. Audio, Mic/Line Level:
1. 22 AWG, 1 Pair, Shielded:
    - a. Single shielded pair cable with overall jacket.
    - b. Conductors: 22AWG (x 2), copper, stranded.
    - c. Shield: 100% aluminum polyester tape, 22AWG tinned copper drain wire.
    - d. Nominal diameter:  $\leq .128$  inches.
    - e. DCR @ 20 deg C: 16.4 Ohms/1000 feet.
    - f. Capacitance:  $\leq 55$  pF/ft.
    - g. Basis-of-Design: Belden 6500FE.
  2. 22 AWG, 1 Pair, Shielded + 22 AWG, 2 Conductor:
    - a. Single shielded pair cable and single non-shielded pair with overall jacket.
    - b. Conductors: 22AWG (x 2), copper, stranded.
    - c. Shield: 100% aluminum polyester tape, 24AWG tinned copper drain wire.
    - d. Nominal diameter:  $\leq .180$  inches.
    - e. DCR @ 20 deg C: 16.4 Ohms/1000 feet.
    - f. Capacitance:  $\leq 55$  pF/ft.
    - g. Basis-of-Design: Belden 6502GE.
  3. 22 AWG, 2 Pair, Individually Shielded:
    - a. Two individually shielded pairs cable with overall jacket.
    - b. Conductors: 22AWG (x 4), tinned copper, stranded.
    - c. Shield: 100% aluminum polyester tape, plus single 24AWG tinned copper drain wire.
    - d. Nominal diameter:  $\leq .158$  inches.
    - e. DCR @ 20 deg C:  $\leq 14.7$  Ohms/1000 feet.
    - f. Capacitance:  $\leq 34$  pF/ft.
    - g. Basis-of-Design: Belden 1325A.
- G. Data/Network/Control:
1. RS-232 / RS-422 / RS-485:
    - a. Single shielded pair cable and single non-shielded pair with overall jacket.
    - b. Conductors: 22AWG (x 2), copper, stranded.
    - c. Shield: 100% aluminum polyester tape, 24AWG tinned copper drain wire.
    - d. Nominal diameter:  $\leq .180$  inches.
    - e. DCR @ 20 deg C: 16.4 Ohms/1000 feet.
    - f. Capacitance:  $\leq 55$  pF/ft.

- g. Basis-of-Design: Belden 6502GE.
- 2. RS-485 plus power (Specialized Media Control Networks):
  - a. Cable configuration: Shielded twisted data pair, plus one unshielded pair.
  - b. For use with products requiring combination power and RS485 data interconnections using a single jacketed cable solution. Sample applicable networks include: Crestron Cresnet™, Biamp Remote Control Bus, Lutron GRAFIK Eye® control bus, and similar RS485 based remote control networks.
  - c. Data conductors: 22AWG, tinned stranded copper, paired.
  - d. Power conductors: 18AWG, tinned stranded copper, paired.
  - e. Shield: 100% aluminum polyester tape, 24AWG tinned copper drain wire.
  - f. Nominal diameter: ≤ .205 inches.
  - g. DCR – data conductors: ≤ 16.3 ohms per 1000 feet.
  - h. DCR – power conductors: ≤ 6.9 ohms per 1000 feet.
  - i. Capacitance – data conductors: ≤ 14.0 pF/ft.
  - j. Basis-of-Design: Belden 1392P.
- H. Power Cables, Low Voltage:
  - 1. Where wire gauge is not specified on the drawings, calculate based on the following requirements:
    - a. Voltage drop shall not exceed 5% of the circuit voltage.
  - 2. 10-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 10AWG (x 2), bare copper, stranded.
    - c. Nominal diameter: ≤ .302 inches.
    - d. DCR @ 20 deg C: 1.07 Ohms/1000 feet.
    - e. Capacitance: ≤ 28 pF/ft.
    - f. Basis-of-Design: Belden 6T00UP.
  - 3. 12-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 12AWG (x 2), bare copper, stranded.
    - c. Nominal diameter: ≤ .252 inches.
    - d. DCR @ 20 deg C: ≤ 1.6 Ohms/1000 feet.
    - e. Capacitance: ≤ 36.0 pF/ft.
    - f. Basis-of-Design: Belden 6000UE.
  - 4. 14-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 14AWG (x 2), bare copper, stranded.
    - c. Nominal diameter: ≤ .210 inches.
    - d. DCR @ 20 deg C: ≤ 2.53 Ohms/1000 feet.
    - e. Capacitance: ≤ 36.0 pF/ft.
    - f. Basis-of-Design: Belden 6100UE.
  - 5. 16-Gauge:
    - a. Single pair cable with overall jacket.
    - b. Conductors: 16AWG (x 2), bare copper, stranded.
    - c. Nominal diameter: ≤ .176 inches.
    - d. DCR @ 20 deg C: ≤ 3.8 Ohms/1000 feet.
    - e. Capacitance: ≤ 36.5 pF/ft.
    - f. Basis-of-Design: Belden 6200UE.

6. 18-Gauge:
  - a. Single pair cable with overall jacket.
  - b. Conductors: 18AWG (x 2), bare copper, stranded.
  - c. Nominal diameter:  $\leq .154$  inches.
  - d. DCR @ 20 deg C:  $\leq 6.5$  Ohms/1000 feet.
  - e. Capacitance:  $\leq 34$  pF/ft.
  - f. Basis-of-Design: Belden 6300UE.

## **2.3 FLEXIBLE / PORTABLE CABLES**

- A. General Requirements:
  1. Flexible / portable cables shall be derived from the system diagrams. Provide all products necessary for a complete and working system including those not expressly identified on the documents.
  2. Cables designed and recommended by the cable manufacturer for portable and/or flexible applications shall be furnished for such applications.
  3. Individual conductors shall be stranded in lieu of solid. Shields shall be braided in lieu of foil only, or foil and drain wire construction.
  4. Flexible / portable cables shall be provided wherever cables are exposed to flexing as a natural by-product of their use. This includes cables furnished expressly for "portable" applications as well as furnished for permanent installation but are routinely exposed to flexing as an inherent consequence of their normal use. This overriding flexible requirement does not apply to cables used in tethers that are subject to flexing less than once per year and the flexing occurs to allow access for servicing of equipment.
  5. Products depicted on the drawings which are not identified by brand and model are the responsibility of the Contractor to furnish and install. The decision whether a Contractor selected product is acceptable remains with the Designer.
- B. Manufacturers: Subject to compliance with requirements, provide products by the following manufacturers:
  1. Canare Cable.
  2. Crestron.
  3. Extron.
  4. Liberty Wire and Cable.
  5. Mogami Cable.
  6. Pro Co Sound.

## **2.4 CONNECTORS**

- A. Video Connectors:
  1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Belden.
    - b. Liberty Wire and Cable.
    - c. West Penn Wire.
    - d. Windy City Wire
  2. 12G-SDI / HD-SDI:
    - a. Connectors shall match the impedance of the cable being terminated.
    - b. Cable connector combination shall allow for a mechanical retention strength of 40 pounds.
    - c. Provide 1-piece compression connector.



**d. Basis-of-Design: Belden HD BNC Connectors****B. Audio Connectors:**

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. Canare Cable.
  - b. Liberty Wire and Cable.
  - c. Mogami Cable.
  - d. Neutrik.
  - e. Pro Co Sound.

**C. Twisted pair Termination Devices:**

1. Furnish cable compliant with Section 271513 "Copper Horizontal Cabling"
2. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. Manufacturers listed in 271513 "Copper Horizontal Cabling".
  - b. Crestron
  - c. Extron
3. General:
  - a. General Performance: Comply with transmission standards in TIA/EIA-568-C when tested according to test procedures of this standard.
    - 1) Twisted pair cable is required to have the appropriate Category classification as defined by TIA/EIA-568-C. Compliance with these electrical characteristics shall be third party verified by the manufacturer.
  - b. Provide the manufacturer recommended termination devices for the cable provided.

**PART 3 - EXECUTION****3.1 CABLE UTILIZATION****A. General:**

1. Where the Contract Documents identify only a general classification of product, the guidelines set forth in these specifications shall be used to determine the cable products to be provided.
2. Where the Contract Documents, including the drawings and related specification do not identify a specific model or classification of product, the guidelines set forth within these specifications in conjunction with recommendations from the manufacturers of the interconnected equipment, and published industry standards and "best practices" shall be used to determine the appropriate product to be provided.
3. Cable that is technically appropriate for the application shall be provided. Cables shall be classified by the manufacturer, in publicly available documents, for their intended use. For example, a cable used for RS232 signals shall be published as rated for RS232 applications. Furthermore, the model provided shall be technically sufficient for the length in which it is used.
4. Provide cable models that are code compliant for the location, use, and method of installation. This includes, but is not limited to, providing plenum-rated cables wherever plenum cables are required by Code.
5. Provide cable that is designed for portable use when the cable may be used in a portable application.
6. Provide cable that is designed and manufactured to endure routine flexing when, by system design, the cable may be exposed to routine flexing.

7. Provide cable models that are designed by the manufacturer for direct burial applications when the cable may come in contact with soil.
  8. Provide cable that allows required system performance to be achieved.
- B. Speaker Cables:
1. Where the use of a specific cable is identified on the drawings, the identified cable shall be provided for the scope identified.
  2. Where the use of a specific cable is not identified on the drawings, cables shall be chosen to achieve no more than 1dB of total power loss in the circuit.
  3. The minimum gauge of speaker cable that may be used in any one-way "constant voltage" speaker circuit shall be 18AWG.
  4. The minimum gauge of speaker cable that may be used in any one-way "low impedance" speaker circuit (2-16 ohms) shall be 16AWG.
  5. Speaker cables used for bi-directional (i.e., two-way) intercommunications shall be shielded and twisted pair type cable.
- C. Data, Serial, Parallel, and Control Cables:
1. Provide cables that are designed and rated by the manufacturer for the format of signal that the supplied cable will be used to transport.
  2. The technical specifications of the cables shall be suitable for the length in which it is used, as well as capable of achieving error-free transmission of the signal at the fastest communication rate supported by the products ultimately being interconnected.
- D. RF Communications:
1. Where RF frequencies are to be transported, provide cables that are designed by the cable manufacturer to transport the frequency range, the voltage and the current that is transported.
  2. Provide cables that are sufficiently shielded to comply with FCC regulations, sufficient to prevent ingress and egress interference that adversely affects the system in which the cable is used, and sufficient to prevent egress interference that adversely affects other equipment and systems.
- E. Low Voltage Power Cables:
1. Provided cables that are used for low-voltage power ( $\leq 70.7$  RMS and  $\leq 100$  Peak) shall be of sufficient gauge to achieve each of the following:
    - a.  $\leq 5\%$  maximum voltage drop between the power source and the load.
    - b.  $\geq 18$ AWG if the cable will transport  $> 500$ ma or its length exceeds 20 feet.
    - c.  $\geq 20$ AWG if the cable will transport  $\leq 500$ ma and its length is than 20 feet.
    - d. Deliver voltage to the load that is not less than the minimum rated input voltage for the load.
- F. Water blocked Cables:
1. Water blocked versions of cables shall be provided when:
    - a. The cable may be exposed to water.
    - b. The cable is installed outdoors.
    - c. The cable is installed below grade.
    - d. The cable is installed within conduit within a concrete slab that is above or below grade, and which there are one or more pull-boxes, junction boxes or other device boxes within the concrete slab along the path of the conduit.

### **3.2 INSTALLATION**

- A. Non-Plenum Cable in Plenum Areas:
  - 1. Where non-plenum cable is supplied and code-compliant installation requires a plenum rating, provide a code-compliant pathway to enclose the cable.
- B. Wiring Within Enclosures:
  - 1. Provide adequate length of conductors. Bundle, lace, and train the conductors to terminal points and achieve clean service loops of appropriate length to the application.
  - 2. Provide maximum possible physical isolation between cables of different operating levels to prevent crosstalk interference that degrades the performance or usability of the system.
  - 3. Replace, reroute, and redress cables that receive or cause negative interference of any form.
- C. Splices, Taps, and Terminations:
  - 1. Install cables continuous and without splices, intermediate connections or terminations between products, except where expressly required by the Contract Documents.
  - 2. When required by the Contract Documents, splices, taps and terminations shall be made within an UL rated enclosure. In addition:
    - a. Cables shall be joined using standardized inline connectors of the type and rating compatible with, and approved by the Designer in advance for use with the cable and signal types being spliced.
    - b. Wire nuts are not permitted.
- D. Drain wire and shield preparation:
  - 1. Non-insulated conductors (e.g., shields and drain wires) that are a part of a multi-conductor cable shall be individually insulated where the conductor exits the cable jacket. The conductor shall be covered with flexible high-temperature heat-shrinkable tubing of a size appropriate to the conductor.
    - a. Green color tubing shall be used except where it conflicts with another conductor's color within the same cable. Clear and white tubing (listed in order of preference) shall be used as necessary to maintain a non-conflicting conductor level color code.
  - 2. When a drain wire or shield conductor is insulated with tubing, as identified above, an additional piece of flexible high-temperature heat-shrinkable tubing shall also be installed over a portion of the cable jacket and the individual conductors where the individual conductors exit the cable jacket. This additional covering shall both insulate the remaining exposed portion of the shield/drain wire conductor and protect it to reduce the risk that this conductor can be bent easier than the manufacturer insulated conductors.
- E. Signal Cable Grounding and Bonding:
  - 1. As a matter of practice, non-signal carrying and non-power passing shield and drain conductors shall be bonded to ground at one end only. The opposite end of the conductor shall be left floating. The shield shall be bonded at the signal sync (load, input) end of the cable. This practice shall be employed to reduce the risks of ground loops between the various interconnected audio components.
  - 2. Unterminated shields and drain wires shall not be cut off. Instead these conductors shall be insulated and prepped for termination and then folded back, protected and secured to the side of the cable jacket or stowed inside the connector shell (where space permits). These conductors shall remain intact and reserved for future and selective use when more challenging ground loop anomalies need to be remediated with the system.
  - 3. Alternate means of handling signal cable shield bonding may be considered when a well-documented grounding and bonding scheme has been submitted for review.

- F. Cable Separation:
  - 1. Cables carrying different signal types shall be kept separate to prevent interference between cables.
  - 2. Cables carrying similar signal types but at different nominal operating levels shall be kept separate to prevent interference between cables.
  - 3. Cables from different systems shall be kept separate to better organize and identify systems as well as to prevent interference between systems.
  
- G. Strain Relief:
  - 1. Cables that are subject to changes in mechanical stress, and, especially those that are used in portable applications, shall be equipped with strain relief.
  - 2. Cables that are probable to connect and disconnect more than once per year shall be equipped with strain relief at each end of the cable.
  - 3. Conductors of cables shall not be exposed to any stress that could deteriorate either the mechanical or electrical integrity of the physical connection between the cable conductor and the connector to which it is attached.
  
- H. Cable Management and Support:
  - 1. Install cables in a neat and organized manner.
  - 2. Route cables parallel to the product in which they are located.
  - 3. Secure cables to wire management products using reusable hook-and-loop type fasteners.
  - 4. Do not use nylon cable ties and other fasteners that pinch and stress cables.
  - 5. Provide cable fasteners that are code compliant for the location and manner of installation.
  - 6. Do not bend cables to a radius that is less than 8-times the cable diameter, nor less than the cable manufacturer's recommended minimum radius.
  
- I. Flexible Cable Management and Support:
  - 1. Provide expandable flexible sleeving:
    - a. Over bundles of two or more cables that have at least one end connected to movable / portable equipment.
  - 2. Provide flexible strain relief:
    - a. Install strain relief products at each end of flexible cable assemblies so that no consequential strain is applied to a signal carrying component of the assembly nor to any connector or terminal to which the assembly interconnects. Size the strain relief to suite the assembly size. Provide an anchor for attachment of the strain relief and ensure that the anchor is attached to a sound structure that will not be damaged if strain is applied.

### **3.3 IDENTIFICATION**

- A. Comply with Section 270553 "Identification for Communications."
  
- B. Provide identification of each end of cables. Nomenclature shall be clearly visible and accurately recorded on the as-built drawings.
  
- C. Use color-coded conductors, color-coded heat-shrink and color-coded permanent adhesive tape to designate individual conductors and cable unit. Record the color code on the as-built drawings.

**3.4 TESTING**

- A. Perform tests of cables after installation to confirm that each is performing effectively as an integral part of the system in which it is used. Test individual cable channels to confirm continued compliance with the Contract Documents and manufacturer's published specifications.

**3.5 FIRESTOPPING**

- A. Comply with Section 270550 "Firestopping for Communications."

**END OF SECTION 27 4101**

**SECTION 27 4103****AUDIO AND VIDEO SYSTEMS SOFTWARE DEVELOPMENT****PART 1 - GENERAL****1.1 SUBMITTALS****A. Control and DSP Programming:**

1. Prior to the pre-construction meeting (described below), submit for review the initial DSP and control programs. Programs shall include the following at a minimum:
  - a. DSP
    - 1) Preliminary program structure including all expected blocks for the system.
    - 2) Speaker voicing based on manufacturer specifications.
    - 3) Appropriate Gain structure based on inputs as shown on plans.
    - 4) Control logic.
    - 5) Preliminary touch-panel layouts if DSP will be used for control.
  - b. Control System
    - 1) Preliminary program structure including all components for equipment that will be controlled by the system.
    - 2) Preliminary touch-panel layouts.

**B. Quality Assurance:**

1. Programmer qualifications (see Quality Assurance).

**C. Closeout:**

1. Electronic Documentation:
  - a. "Copyright, Ownership and Licensing Declaration" as described elsewhere in this Section, PDF version.
  - b. Storyboarding / flowcharting documentation, PDF version.
  - c. Software source code files.
  - d. Touch panel and other graphical user interface source code files.
  - e. Compiled graphics files.
  - f. Editable layered graphics files for Project specific custom graphics.
  - g. Current-version device drivers for controlled devices.
  - h. Controlled-device protocol documentation.

**1.2 REVIEW MEETINGS****A. Pre-Construction Review**

1. Prior to commencing on-site construction, the contractor shall attend a meeting at KLH Engineers to review the client expectations and system design considerations. The meeting shall not be scheduled without reviewed submittals including the reviewed program submittal described above. At a minimum, the project manager and system

programmer for the contractor shall be present. This meeting shall not exceed four (4) hours in length and will cover the following topics at a minimum:

- a. DSP structure and programming.
- b. Control panel design.
- c. Speaker aiming angles as designed and modeled by KLH.
- d. Staff qualifications.
- e. Testing and balancing materials and methods.

**B. Post-Construction Review**

1. Upon substantial completion of the system, the contractor shall meet on-site and demonstrate the operation of the system to KLH personnel for review. KLH will review the operation of the system based on the system drawings and the Pre-Construction meeting to ensure the system adheres to the design intent. The system should be fully tested and tuned prior to scheduling this review. This review shall not exceed four (4) hours in length.

**1.3 PRICE AND PAYMENT PROCEDURES**

**A. Payment Procedures:**

1. Requests for payment for Work will not be considered until Phases 1, 2 and 3 of the software development has been completed.
2. Progress payments for shall not be considered without electronic submission of Work progress. See also "Penalties for Non-Performance."

**1.4 REFERENCES**

- A. InfoComm International's publications: "Modern Approaches to Control Systems Design", <http://www.infocomm.org/>.

**1.5 DEFINITIONS**

- A. Controlled Device: A product with which the Software communicates. A controlled device is a physical or software-based product that receives commands/data from, or sends commands/messages/data to, the Software.
- B. IR: Infra-Red.
- C. GUI: Graphical User Interface.
- D. User Interface: Any physical or software-based product, custom or standard, that connects to and/or communicates with the control system and Software for the purpose of providing interactive interface between a system user and the Software.
- E. Software Developer: The entity responsible for performing Work of this Section.



**1.6 QUALITY ASSURANCE**

- A. Comply with Section 270002 "Quality Assurance for Communications."
- B. Programmer Qualifications:
  - 1. Control Systems:
    - a. Manufacturer Certified Programmer. Certification shall be, at minimum, equivalent to Crestron Master Certified – Silver Level.
    - b. Resume of 20 programs or 5 years full-time computer programming experience.
  - 2. Shall be a full-time employee of the company providing the Division 27 41 00.00 work. Programing subcontractors are not permitted.

**1.7 SOFTWARE LICENSING AND OWNERSHIP**

- A. Supply a perpetual, irrevocable and royalty-free global license to use Software Work.
- B. Grant to the Owner the following number of licenses:
  - 1. One for each Audio and/or Video system identified in these Contract Documents.
- C. Source Code:
  - 1. Furnish fully editable source code for each processor, user interfaces and other control electronics.
  - 2. Layered electronic graphics files shall be furnished for user interface graphics.
- D. Rights to Modify Source Code:
  - 1. The Owner shall have the right to view and modify the source code and other files supplied. The Owner shall have the right to change the Software in any way it deems necessary, including but not limited to the right to evolve the Software to accommodate equipment changes, additions, deletions, or functional changes to the system.
- E. Payment of Licensing Fees:
  - 1. The Software Developer is responsible for properly licensing and making payment for any Software modules and graphics incorporated into Software Work, including license fees arising from the use of any part of software furnished by the Owner for the Software Developer's benefit in creating Software Work.
- F. Copyright, Ownership and Licensing Declaration:
  - 1. In the event the Software Developer incorporates copyrighted work from any third-party entity into the Software Work, the Software Developer shall declare the lawful copyright holder and include valid contact information for the entity.
- G. Non-Disclosure:
  - 1. The name of the Owner may not be used in any advertisements, publications, lectures or any other public medium as it relates to the Software Developer's role in creating this Software Work.
  - 2. The Software Developer may not reuse or demonstrate Software Work or any portion thereof that includes the name of the Owner, references to the Owner, copyrighted material obtained from the Owner, or any other trade or service mark that could identify the Owner.

3. Should the Software Developer desire the right to publicly reference the Owner in any way, including demonstration of Software Work to others, the Software Developer shall obtain the express permission from the Owner, in writing.

## **1.8 WARRANTY**

- A. Software furnished shall be warranted for a period of 365 days following final acceptance of the Software Work.
- B. During the warranty period, the resources necessary to resolve Software bugs shall be provided at no cost to the Owner. Software bugs that are catastrophic in nature shall be resolved within 3 business days following their report to the Software Developer by the Owner. Non-catastrophic bugs shall be resolved within 30 days.
- C. Software bugs are defined as:
  1. Any Software feature, operation, behavior, or mode that makes the system unstable or operationally unusable for the Owner's intended use of the system.
  2. The absence of any Software feature, operation, behavior, or mode determined necessary during the Software development phases that has not been implemented, not implemented completely, or not implemented reliably.
  3. Any Software feature that does not perform in the manner agreed to by the Owner's representative, or that otherwise performs in a manner that is counter-productive to the task to be performed by the Control System.
  4. The absence from the Software of any feature, operation, behavior, or mode expressly identified in the Contract Documents and not otherwise expressly removed from the Project scope in writing by the Designer.
  5. Incorrect labeling or misspelling of text on a programmable user interface.

## **1.9 MAINTENANCE**

- A. Following final acceptance of the Software, the Software Developer shall return to the Project site at planned 30, 90 and 180-day intervals to make minor adjustments to the Software. The Software Developer shall contact the Owner at each interval to determine what, if any, Software adjustments are necessary. The Owner reserves the right to use these visits any time during the warranty period.

## **PART 2 - FUNCTIONALITY**

### **2.1 GENERAL**

- A. This Section is not a programming Manual. In general, this Section describes the capabilities and functionality expected of the Software product used to control related AV systems. The Software Developer shall be fluent in programming skills and well versed and experienced with the operational and programming needs of systems of the size, type, and complexity as those for which the Software is to be developed.
- B. This Section applies to multiple systems. Due to the presence of different equipment in each system, and the possible use of equipment with various capabilities, functionality described herein may not be completely possible with each system.

1. Example: An AV system without remote controllable audio equipment shall not be required to have Software written with audio control capability unless express written direction to the contrary is identified.
- C. System functionality that is described in related Sections and Drawings that can only be achieved using custom Software are additive to the requirements of this Section. Review related Sections and Drawings.
- D. Due to the differences between products, including differences between products of like type, no attempt has been made to enumerate every remote-control function, operation and behavior that shall be accommodated by the Software.
- E. Functions described in the Contract Documents may not directly be available on the product being controlled. In such cases, functionality shall be achieved through development of suitable Software modules (e.g., intelligent macro) to achieve the desired effect. In select cases, the Designer or Owner may conclude the function is no longer required:
  1. Example: A motorized drapery or screen may not have an inherent "Preset" function. Therefore, a preset function may need to be emulated in the Software by timing the motor to run for a defined duration from a known position.
- F. Functionality and behaviors articulated in the Contract Documents are requirements of the Software Work until or unless otherwise modified and agreed to, in writing, with the Owner's Representative.

## **2.2 PERFORMANCE**

- A. The Software performance shall be robust, predictable, reliable and stable.
- B. User interfaces shall accurately reflect the state of the system and controlled devices.
- C. Normal use of the system, including new-user encounters with the system, shall not result in a lock up of any portion of the system.
- D. System operation shall be restored to normal following a power failure to any controlled component or a control component. System and personnel-safe conditions shall be ensured by the Software following such conditions.
- E. The Software shall perform to the satisfaction of the Owner's representative.

## **2.3 SOFTWARE-AWARE PROGRAMMING**

- A. The Software shall employ a coding methodology herein referred to as "Software-Aware programming."
  1. Software shall be aware of and locally buffer the status of the properties of a controlled device. This shall be true regardless of whether the settings of a controlled device are changed by this Software via a device's local user interface, an external Software interface, a third-party software application, or by other means.

- a. Example 1: If a projector input is changed, the Software shall be aware of the current projector input change.
    - b. Example 2: If the program audio gain is changed using a third-party client application, the Software shall be aware of the current gain value.
    - c. Example 3: If a user presses play on a Blu-ray player, the Software shall be aware that the Blu-ray player is playing.
  2. Software shall be aware of the current settings of controlled devices that are material to achieving accurate, responsive, and repeatable AV System performance under Software control.
  3. The Software shall leverage up-to-date information of the status of a device to achieve expedient and accurate logic decisions.
  4. Software user interface shall accurately represent the state of a device when the associated device status display is visible.
  5. Software decisions shall be made reliably, without having to routinely query a controlled device for a response immediately before taking the next logical step.
  6. Software Aware programming shall not rely on real-time on-demand polling for making routine logic decisions.
- B. In Software Aware programming, the Software shall not send commands to a controlled device to perform an action that the controlled device is already performing.
1. Example 1: If a video projector needs to be on Input 1 in order to display the most recent source selection, and if the projector is on Input 1 at the time the source selection is made, then the projector shall not be sent a command to change inputs, since it is already on the one it needs to be on. Conversely, if the projector had been changed to Input 2 (by the Software or other means), then the projector shall be switched to Input 1.
    - a. In this example, commanding the projector to switch to an input that is already active may cause video resynchronization which may result in a blank screen, flickering or other unnecessary and undesirable visual effects. It may also slow the responsiveness and performance of the system.
  2. Example 2: If a matrix already has Input 12 assigned to Output 14, the matrix shall not be sent a command to assign Input 12 to Output 14. Doing so may slow down the responsiveness and performance of the system.
- C. Software Aware programming requires a strategic mix of the following techniques:
1. Querying a controlled device to obtain critical device status properties.
  2. Querying controlled devices in the background, in a controlled manner, when the user is not actively making changes to the system.
  3. Monitoring and processing events and command acknowledgements of a controlled device software.
  4. Processing status messages received from controlled devices.
  5. Buffering device properties locally, within the control system hardware using arrays, objects, buffers, and modules.
  6. Highly modular, flexible and professional Software coding techniques.
- D. In Software Aware programming, a two-way touch panel shall accurately display settings of a selected device immediately when the device control page is activated. One second (or longer) delays while the Software queries the device and then processes and reports the status to the user shall not be acceptable.
- E. Software Aware programming requires advanced programming skills and experience.

- F. Appropriately employed, Software Aware programming techniques shall result in Software performance that is robust, responsive, familiar, fast performing and does not result in Software induced, Software preventable aural or visual glitches.
- G. User interfaces that are part of a Software Aware programming solution shall be highly responsive to user stimulus to such an extent that users are not inclined to execute a command a second time because of a lack of user interface responsiveness.

## **2.4 USER INTERFACE FEEDBACK**

- A. General:
  - 1. Implement controllable feedback on user interfaces (i.e., sound, lights and color change) as a means to achieve the following:
    - a. Supply an immediate acknowledgement to the user that the command has been received. Examples include the following:
      - 1) Changing the color of a button immediately in response to the user touching the button.
      - 2) Playing a sound in response to the user touching the button.
    - b. Supply immediate responses to the user to indicate the status of the command request. Examples include the following:
      - 1) Illuminating a power indicator "Green" when a device is powered up and ready for use.
      - 2) Illuminating a power indicator "Red" when a device is powered down and available to be power back on.
      - 3) Illuminating a power indicator "Flashing Red" when a device is in process of powering down.
      - 4) Illuminating a power indicator "Flashing Yellow" when an operation is in process.
      - 5) Displaying a progress bar while device is powering up and down and if this information is necessarily material to the user's next actions.
  - 2. Where the user interface capability permits, supply separate means of achieving feedback to the user. Examples include the following:
    - a. Use a temporary button color change as an acknowledgement that the button has been pressed and was acknowledged by the system.
    - b. Use LED-like indicators to communicate device status.
- B. Managed Feedback:
  - 1. Feedback reporting shall be accurate and appropriate for the device(s) under control, including reporting of status changes that occur through direct interaction with a controlled device or other means.
    - a. Example 1: If the user makes a manual signal routing change via the control panel on a matrix, the Software shall monitor the matrix's events, or controlled background querying, to be aware of the change so it can be correctly reported to the user interface.
    - b. Example 2: If the user hits play directly on a media player, the Software shall be aware of the change and correctly report that the media player is playing.
  - 2. When status information returned from a device to the Software is delivered slowly, (not fast enough to directly deliver an immediate response to the user) then a hybrid feedback solution shall be implemented. The hybrid solution shall result in immediate feedback to the user acknowledging their action, followed by command status feedback to advise the status of the request.

- a. Example Situation: A lighting system takes 3 seconds to acknowledge a successful change from “Preset 1” to “Preset 3” following a user’s command to change.
  - 1) Example Solution:
    - a) Step 1: The “Preset 3” button immediately changes colors while it is being pressed as a means for the Software to acknowledge it has received the command. The button returns to normal color after the user’s finger is removed from the button.
    - b) Step 2: The Software initiates the request of the lighting system to change presets, and immediately begins to flash the “Preset 3” status indicator.
    - c) Step 3: The “Preset 3” status indicator illuminates solid on when the lighting system completes the transition to “Preset 3.”
- b. Example Situation: A video projector takes 30 seconds to warm up, does not supply a warming-up status message, and does not acknowledge that it is On until after it is fully warmed up and ready for use:
  - 1) Example Solution 1:
    - a) Turn off the Power Off indicator and immediately begin flashing the projector Power On indicator.
    - b) Once the projector acknowledges that it is On, change the projector Power On indicator from flashing to constant.
  - 2) Example Solution 2:
    - a) Use a progress bar or similar control that communicates that the projector is warming up, incrementing the bar to emulate the warming process. Hide the progress bar, turn on the projector Power On indicator and turn off the projector Power Off indicator once the projector acknowledges it is On.
- c. The manner in which hybrid solutions are deployed in the Software shall be as consistent as technically possible throughout the Software.

**C. Infra-Red (IR) Controlled Devices:**

1. Supply emulated status information for one-way controlled devices that do not otherwise supply status feedback. Review logic options with the Owner’s representative. In select cases, momentary feedback may be acceptable.

## **2.5 CONTROL METHODOLOGY**

- A. To enhance overall Software performance, bi-directional communication control methods shall be used with controlled devices wherever possible in order to take advantage of device status information. Common bi-directional communication control methods include:
  1. RS232.
  2. RS485.
  3. RS422.
  4. TCP/IP.
- B. Single direction communication control methods shall be used only where expressly specified or where it is the only method of control available on a specified product.
- C. Hybrid / Dual-Control communication methods shall be used when required functionality cannot be achieved through a single communication port. Such may be the case in a product that can achieve 98% of the desired functionality via its RS232 port, and the remaining functions are only available on an IR port. Hybrid methods shall be used as necessary to improve the stability and robustness of the Software application.



## **2.6 USE OF PRESETS OR MACROS**

- A. The Software shall not use preset or macro functions of a controlled device if:
  - 1. Use results in system performance that is slower than it would be if the applicable settings on the device were managed directly by the Software
  - 2. Use results in the loss of video or audio at any critical point in the system.
  - 3. Use results in any perceptible video or audio artifacts.
  - 4. Use results in negative effects on the system use or performance.
  - 5. Use results in any undesirable level or signal routing changes.
- B. Research the use of controlled-device presets or macros to obtain a thorough understanding of impact on the system performance. Use of presets and macros requires review and authorization of the Designer.

## **2.7 BEHAVIORS**

- A. General:
  - 1. The Software shall be written to include behaviors that would be considered familiar (i.e., intuitive) to the system users. Such familiarity may be derived from interaction with various other real-world interfaces such as personal computers, car radios, IPODs™, microwave ovens, home entertainment equipment or other products.
- B. User Interfaces:
  - 1. User interface designs shall employ navigational schemes that limit the number of steps and interface layers that a user must navigate in order to perform a desired action. The more frequent a command must be executed in real-world use, the fewer actions the user shall be required to take in order to achieve the goal.
  - 2. One of the major objectives of Software user-interface design is to enable simple control of otherwise complex systems.
- C. Audio Breakaway and Audio-Lock:
  - 1. Software shall incorporate functionality that permits the user to achieve the following:
    - a. Listen to audio from a multi-media (i.e., program) source without the necessity of having a video display powered on.
      - 1) Example: Listen to music or a lecture from audio-only media.
    - b. Listen to audio from a multi-media (program) source, while viewing the video from a different source:
      - 1) Example: Listen to audio from a PC, while displaying video from a document camera.
  - 2. AV systems with two or more video displays (used for audience/participant viewing), Software shall include the ability to listen to the audio from either (but not both) of the visible multi-media sources.
  - 3. When changing the active multi-media source, audio switching shall function, by default, as an audio-follow-video switch, whereby a change in the video source, also results in a corresponding audio switch as well.
  - 4. In addition, an on-demand Audio-Lock feature shall be implemented to achieve the following:
    - a. Stop subsequent audio-follow-video switching.
    - b. Continued manual audio source assignment.



**D. Multi-Level Multi-Media Source Selection:**

1. When user-interfaces featuring Graphical User Interface capability (i.e., touch panels) are used, and the user interface layout includes an approved two (or more) level approach to multi-media source selection, the Software shall include behavior that does not require the user to make a subsequent selection on the lowest level menu, unless the desired selection differs from the last selection.
  - a. Example: A level-one source select menu is implemented with the following choices: PC, Laptop, Doc Cam, Blu-ray, DVD, and Floor Pocket. The Floor Pocket has four (4) inputs. Touching the Floor Pocket source selection exposes a level-two source select menu that includes each of the four (4) floor pocket inputs. When the level-one Floor Pocket button is pressed, the level-two menu shall appear, the last used floor pocket input shall be active, and the signal associated with the last selected floor pocket input shall be routed to the associated display. The user shall not be required to make a level-two choice, unless it differs from the last selection. The act of pressing the Floor Pocket source select button therefore shall also have the effect of making active the last floor pocket input selection.
2. At system initiation, default assignments shall be made for level-two source selection menus.
3. This multi-level approach shall be employed similarly to other applicable controls. Deviation from this methodology shall occur only with written approval.

**E. Video Display Power Up:**

1. Audience/Participant Video Display(s) shall, by default, power up under the following conditions:
  - a. The user assigns a video enabled multi-media source to the video display.
  - b. The user manually powers up the video display.
2. Video displays shall not automatically power up when the System is powered up, unless this feature is deemed appropriate during the Software Development review with the Owner's representative.

**F. Video Swap:**

1. A video swap feature shall be implemented in systems with two or more video displays serving the audience/participants. This feature is applicable when the AV system includes the inherent capability to route video signals to each display independently. The video swap function shall re-route/swap the video images on the two displays. The swap shall be temporary. Subsequent video multi-media assignments made by the user shall route to and appear on the correct user-designated display.
2. When a video swap is performed, the system user interface(s) shall correctly reflect the assignment.

**G. Audio Level Changes:**

1. Audio level changes shall occur in real time. Audio level adjustments shall commence when a control is touched and shall cease immediately when the control is released. Audio changes shall not occur subsequent to the release of the control.
2. The rate of increase and decrease of audio settings shall be field adjusted to the satisfaction of the Owner's representative. Depending upon the product being controlled, this adjustment may require that the unit of change per cycle and/or the cycle/repetition rate (among others) be modified.
3. Bar graphs (and similar level reporting devices) shall accurately represent the relative gain of the device under control. This includes accurately displaying the gain settings anytime the bar graph is visible to the user, including immediately following a power up cycle, and following the recall of a preset or macro.

- a. In the interest of performance, the Software Developer shall consider coding and control techniques that favor responsive control of a device by using a hybrid feedback solution while adjustments are being made. For example:
      - 1) If processing of gain status messages returned from a device causes delays in the speed at which commands to increase or decrease the level can occur, then locally emulating the level changes on the bar graph may be necessary. A subsequent release of the level control shall then be used to trigger an accurate refresh, or the bar-graph based upon the devices actual gain setting. The bar graph and actual device values shall match.
  4. Use Software variables that are readily accessible to a technician and that do not require recompiling of Software.
- H. Limited Range Controls:
  1. User adjustments benefit from range limit settings. Where range limiting benefits the Owner, the Software Developer shall implement accordingly.
    - a. For example: The presenter microphone gain control may have a maximum gain that can be applied to it before acoustic feedback occurs. The same microphone may have minimum usable gain setting (e.g., one where the gain is not usable for a very loud-spoken presenter). The specific limits of the controls shall be determined in the field during system testing and demonstration with the Owner's representative.
- I. Preset Status – Correct Reporting:
  1. When a device is assigned a preset / scene by use of the Software, or by other means, the Software user interfaces shall correctly report the preset / scene currently active.
  2. When either the Software user or an external user makes a manual change to a controlled device, and such change may mean that the device is no longer representing the preset / scene last selected, then the Software shall deactivate the user interface feedback that indicates the last scene selection.
    - a. For Example: If a camera is instructed to go to Preset 1 and the camera complies, then the Preset 1 status indicator shall become active. If the user subsequently manually changes a camera position, the camera is no longer at Preset 1. Therefore, the act of manual repositioning shall result in the deactivation of the Preset 1 indicator.
- J. Disable Controls Not Applicable in Current Context:
  1. The Software user interface shall expose only those controls that are applicable to the current context and operations. If a control has no purpose within the current context, the control shall either be hidden or systematically grayed out to indicate it is disabled, unusable and out of context.
    - a. Example 1: If an interface features three computer select buttons, and within the context of desired operation, one of the computers is in use by another room and it is (by design) not to be accessible locally, then the select button for the inaccessible computer shall be inoperable and either grayed out or hidden.
    - b. Example 2: A user interface includes source select buttons along the top of the screen. Operationally, if assigning a source requires a destination selection button to be visibly active, then if the destination button is neither active nor visible (because of another operation in process), the source select buttons shall also be disabled and grayed out or hidden.
    - c. This theme can be observed using various Microsoft Windows™ applications that gray-out selections that are not applicable in the current context.
  2. Disabling and/or hiding of controls shall be handled in a consistent manner throughout the Software.

## **2.8 DEFAULT SETTINGS**

- A. Software shall ensure that controlled devices are in a known state when the system it controls is powered on, off, or placed into or taken out of standby.
  - 1. Default values shall be set when the system is powered off so that in the event the controlled system is powered up using a means other than the control system interfaces, the system shall power up to a known state.
- B. Default settings shall include, but shall not be limited to:
  - 1. Volume settings.
  - 2. Switcher / matrix settings.
  - 3. Mode settings.
  - 4. Video and audio processor settings.
  - 5. Screen positioning.
  - 6. Display status.
  - 7. Others as determined appropriate and necessary by the Software Developer and the Owner's Representative.
- C. Properly deployed default settings shall guarantee that proper settings are set in controlled devices when the system is powered on, regardless of what the settings were when the system was last used, and regardless of what setting changes may have been made locally to a controlled device by the user.
- D. Default settings shall be stored in a non-volatile memory location of the control system components.

## **2.9 CONTROLLED DEVICES**

- A. General:
  - 1. Refer to related Sections and Drawings for identification of controlled devices. Controlled devices include:
    - a. Control system products appearing in the Drawings.
    - b. Products appearing on control system diagrams.
    - c. Products noted on control system diagrams as being connected to or otherwise communicating with the control system.
    - d. Products appearing in system diagrams and noted as being connected to the control system.
    - e. Products noted on related Drawings.
    - f. Products identified in related Sections.
  - 2. Following are various controlled products that may be encountered, as well as common device-specific functions that shall be performed.
- B. Multi-Media Sources:
  - 1. Blu-ray, DVD, and similar devices:
    - a. Play, Stop, Pause.
    - b. Fast-Forward, Fast Reverse.
    - c. Step-Forward, Step Reverse.
    - d. Counter-Reset.
    - e. Power On/Off.
    - f. Channel Up/Down.

- g. Discrete Channel and track selection.
    - h. Channel Display On/Off.
    - i. On-screen Display On/Off.
    - j. Closed Caption On/Off.
    - k. Menu Navigation Controls.
  - 2. Document Cameras:
    - a. Zoom: In, Out.
    - b. Focus: In, Out.
    - c. Top Lights: On, Off.
    - d. Base Lights: On, Off.
    - e. Camera Up, Camera Down.
    - f. Power On, Power Off.
    - g. Presets Recall.
    - h. Preset Storage.
- C. Recording Equipment:
  - 1. Blu-ray, DVD, DVRs, NVRs
    - a. Play, Stop, Pause, Record.
    - b. Fast-Forward, Fast Reverse.
    - c. Step-Forward, Step Reverse.
    - d. Counter-Reset.
    - e. Counter/Track/Chapter Display.
    - f. Finalize/Close Disc.
- D. Video Display Equipment:
  - 1. Source selection based control.
  - 2. Manual signal routing.
  - 3. Power On/Off.
  - 4. Standby/warming-up/cooling-down messages.
  - 5. Lamp status/hours used/hours remaining.
  - 6. Video mute.
  - 7. Video freeze.
  - 8. Alignment controls.
  - 9. Menu navigation controls.
- E. Cameras:
  - 1. Pan, Tilt, Zoom.
  - 2. Storage and recall of presets, as required for the intended operation of the system:
    - a. Separate preset registers shall be implemented for each room layout.
    - b. Separate preset registers shall be implemented for each mode of camera automation as deemed necessary.
- F. Microphones:
  - 1. Software control of Status Lights/LEDs.
  - 2. Software monitoring of switch status, followed by execution of desired actions.
- G. Lighting Systems:
  - 1. Control of lighting levels of discrete lighting zones: Up, Down, Off.
  - 2. Recall of presets.
  - 3. Monitoring and display of current lighting preset(s).
  - 4. Store lighting presets.

- H. Drapes, Shades, Curtains, Screens:
  - 1. Up, Down, Open, Close, Stop.
  - 2. Recall presets.
  
- I. Routers and Matrices – Audio, Video, Data:
  - 1. Source/Destination based switching.
  - 2. Audio and Video breakaway switching.
  - 3. Manual switcher control.
  - 4. Input trim levels.
  - 5. Preview.
  
- J. Switchers – Audio, Video, Data:
  - 1. Source/Destination based switching.
  - 2. Audio and Video breakaway switching.
  - 3. Manual switcher control.
  - 4. Input trim levels.
  - 5. Seamless transition.
  - 6. Preview.
  
- K. Audio Products:
  - 1. Gain Up/Down.
  - 2. Mute.
  - 3. Routing.
  - 4. Preset Recall.
  - 5. Macro Recall.

## **2.10 CAMERA AUTOMATION**

- A. Systems with cameras for video teleconferencing, broadcasts, recording and similar uses shall implement camera automation modes to manage which camera(s) and camera position(s) are active based upon various criteria. Common modes that shall be accommodated in the Software include the following:
  - 1. Push-To-Talk.
  - 2. Push-To-See.
  - 3. Automatic (gate based).
  - 4. Queued – First in, first out (i.e., manual “Next Question” selection).
  - 5. Manual Telemetry Control.
  - 6. Manual Preset Recall.
  
- B. The behavior of each mode shall be established during Software development.
  
- C. Camera automation shall regulate camera positioning and switching so that camera movement is not normally seen when the camera is live. This requires camera queuing and pre-positioning before the camera is made live.
  
- D. Visible movement from a camera shall only occur when a user manually positions a camera after it is live.

- E. Camera automation shall permit camera(s) to be taken out of service when a camera fails or is otherwise not available for use, and the remaining camera(s) shall pick up the work load of the camera(s) that are not available.
- F. The Software shall support multiple room configurations, where applicable, and shall manage separate camera selection and preset values for each configuration.

#### **2.11 PREVIEW AND CONFIDENCE MONITORING**

- A. Where the system under control is equipped with video preview and confidence monitoring equipment, the Software shall enable preview and confidence monitoring in a manner agreed to during Software development.
- B. When, where, what and how signals are triggered for monitoring shall be determined during Software development.

#### **2.12 GLOBAL MONITORING AND CONTROL**

- A. Control systems shall be programmed to communicate with, be controlled by, and supply status and statistical data to global management software, as applicable to the brand of control system hardware used on the Project. Sample applications include but are not limited to: AMX Media Manager and Crestron Room View.

#### **2.13 HELP REQUEST**

- A. User interfaces shall incorporate a "Call for Help" or similarly labeled button. This button shall be used to send an email, trigger the sending of a numeric or text page, or send a command/message to any other notification device connected to the system.
- B. The specific action taken shall be as agreed to during Software development.

#### **2.14 HELP MESSAGES**

- A. Graphical user interfaces shall incorporate the use of text-based help messages and operating instructions.
- B. Unless additional help messages are requested elsewhere in the specifications, at a minimum provide one unique pop-up style help message for each controlled device.
- C. Help messages shall be context sensitive. The message presented to the user shall be relevant to the current user interface view and mode at the time the button is activated.
- D. The manner in which the messages are activated and presented to the user shall be determined during Software development.

**2.15 E-MAIL MESSAGING**

- A. Software shall include provisions for sending automated email messages from the system.
- B. Up to 20 distinct email messages shall be programmable into each system.
- C. The system events that trigger messages shall be determined during Software development.

**2.16 SHUTDOWN TIMERS**

- A. General:
  - 1. Timers shall be implemented to shutdown select equipment or a complete system as described herein.
  - 2. Timer values shall be consistent values, stored in non-volatile memory.
  - 3. Time-of-day shutdown timers shall include a one-time-only bypass capability, whereby the user can instruct the system to bypass the next logical shutdown event so that shutdown will not occur at the next regularly scheduled time.
  - 4. Prior to automatic shutdown, the Software shall present a message on the various graphical user interfaces warning of a pending system shutdown. The message shall present options to the user, including options to shut down now, ignore the shutdown event altogether, or extend/delay shut down by a fixed amount of time. The amount of the advance warning and the amount of the time delay shall be determined during Software development. Initial values shall be five (5) minutes and one (1) hour.
  - 5. Shutdown parameters shall be changeable by an advanced user or system administrator without the aid of a programmer. Updating these parameters shall be achieved through the use of one of the system's user interfaces, PC interface or database provided by the Software Developer.
  - 6. If suitable replacement timers are incorporated into global monitoring and control application, local timers may not be necessary.
- B. Visual Display Shutdown Timers:
  - 1. Auto shutdown timers shall be programmed to place displays into standby or equivalent state, based upon various conditions. Common conditions include:
    - a. When a display has been assigned a Black or Blank source, a countdown timer shall commence that places the display into standby when the countdown timer reaches Zero.
    - b. When a predefined time of day is reached.
  - 2. Display shutdown timer durations shall be global; however, each display shall feature a unique timer.
- C. System Auto Shutdown:
  - 1. Automatic system shutdown timers shall be programmed to power down the system under the following conditions:
    - a. When a user defined time of day has been reached.
    - b. After a user defined period of user interface inactivity.
  - 2. Two separate time-of-day shutdown timers shall be programmed. One shall be used for weekends, and one shall be used for weekdays.
  - 3. When a global management application is used, system auto shutdown timers may be relegated to the global management application instead of the local Software provided this is agreeable to the Owner's representative.



D. Special Circumstance Timers:

1. Where controlled devices other than those represented here are prone to excessive wear, operating or maintenance expense when left in a particular state, the Software Developer shall implement additional discrete timers adapted to the product. Software Developer shall consult with the Designer to determine which controlled devices may require special timers.

## **2.17 DATE, TIME, CLOCK AND TIMERS**

A. Setting Date and Time:

1. The Software shall include the ability for the Owner to set the current date and time or feature an agreed upon alternate method for ensuring that the current date and time is accurate (e.g., network time server).
2. Special software or a programmer shall not be required to set these values.

B. User Interface Clock and Timer:

1. The Software shall incorporate clocks and timers on the user interfaces, visible at such locations as agreed to during Storyboarding, as described in Part 3 below.
2. Clocks shall be configured to permit 12-hour and 24-hour time. Consult with the Owner's representative.
3. Clocks shall be configurable to allow operation as timers. Each shall be programmed to achieve count-up and count-down operation. The user shall have the ability to switch between the various modes of operation.
4. Count-up and Count-down timers shall also be programmed to present some form of indication to the user that warns time is about to expire. The appearance of this indication (e.g. color change, dialog box, flag) shall be determined during Software development. Means shall also be included for a technician to change the warning period, means that does not require recompiling Software.

## **2.18 MODES OF OPERATION**

A. The Software shall include multiple modes of operation to suit the needs of the Owner. Common modes include the following:

1. Normal Mode.
2. Executive or Simple Mode.
3. Advanced Mode.
4. Administrative Mode.

## **PART 3 - EXECUTION**

### **3.1 DEVELOPMENT PROCESS**

A. General:

1. Software Development shall be the responsibility of the Software Developer.
2. Development shall be a multi-phased interactive and iterative process lead by the Software Developer. Development shall involve input from, and interactive review with, the Owner's representative.
3. Development shall begin not less than two weeks after award or notice of intent to award. Work shall be completed within such timeframe as to permit Work to be completed prior to the Owner's scheduled completion date(s).

4. The Software Developer shall closely collaborate with parties providing related Work.

**B. Development Phases:**

1. Phase 1 – Needs Analysis:
  - a. This phase shall be used to refine the general expectations of the Software for each system that the Software controls, from a very high level perspective.
  - b. One or more meetings per system shall be expected.
  - c. The first meeting shall be scheduled within two weeks following Contract award, and the first meeting shall be held within three weeks following Contract award.
  - d. Information gathered during this phase, in the Contract Documents, and in subsequent development phases, shall be used to evolve expectations of the final Software Work.
2. Phase 2 – Storyboarding / Flow-Charting:
  - a. The Software Storyboarding / Flow-Charting phase (henceforth called Storyboarding or Storyboards) shall be where the Software Developer creates physical documents to depict the navigational flow of the system (from a user interface/operation standpoint) and document the operation of the Software relative to the system(s) being controlled.
  - b. This shall be an iterative phase whereby the Developer creates, presents, discusses and revises storyboards until there is a mutual agreement with the Owner.
  - c. At the conclusion of this phase, the resulting documents shall include information that:
    - 1) When reviewed by the Owner, the documents clearly communicate the operation and behavior of their system.
    - 2) When reviewed by a qualified programmer (including one with no prior knowledge of the system that the Software controls), communicates sufficiently to permit the writing of code that would meet the requirements of the Contract Documents and the intent of the Owner.
    - 3) When reviewed by the system installer, clearly communicates the intended operation and behavior of the system.
  - d. Storyboards shall be presented in hard-copy form on paper, either 24 inches by 36 inches or 30 inches by 42 inches in size.
  - e. Storyboards shall evolve to contain images of the permutations of each user interface. User interface images shall be drawn and interconnected in a flow chart fashion, and each element of the user interface shall be represented and described. Each button that performs a navigational action shall be interconnected to the view that results. Buttons performing an action shall also be described. The reader of the storyboard shall be able to follow it like a map, navigating through the operation of the system from start-up to shut-down and how to take advantage of features of the Software in-between.
  - f. The representations of user interfaces shall be presented as black on white line drawings, without graphic elements or color. Graphic elements and color on the storyboard representations at this phase routinely causes loss of functional focus and shall be avoided. Color may be used for annotations, interconnecting lines, and flow-chart logic and action text to enhance readability or flow interpretation.
  - g. Storyboards shall be used for graphical user interfaces (i.e., touch panels, client applications, web interfaces) as well as non-GUI type user interfaces (i.e., push-button panels).
  - h. The duration between review meetings covering a single user interface shall be kept as short as is practical, preferably not more than (2) to (3) days.
3. Phase 3 – User Interface Development:
  - a. This phase shall result in the final appearance and operation of each user interface. This is an iterative process conducted between the Software Developer and the Owner's representative.

- 1) This phase shall involve reworking of the storyboards to accommodate modified Software flow, behaviors and conditions not evident or fully understood during prior phases.
- b. This phase includes the following:
  - 1) Creation of real world user interfaces based upon the storyboarding documents.
  - 2) Development and implementation of graphics.
  - 3) Final sizing, shaping and positioning of buttons, indicators and text.
  - 4) Identification and assignment of color themes.
  - 5) Creation/implementation of companion emulation Software that brings the user interface to life and enables evaluation of appearance, operational and navigational flow, behavior, and general responsiveness. Acceptable emulation Software allows the user interface to behave as though it were actively controlling the associated system.
    - a) Emulation Software includes: (a) Full navigational operation, (b) Button feedback, (c) Device status emulation, (d) System status emulation, (e) Working screen changes, page changes, pop-ups and messaging, and (f) Variable text change emulation.
- c. This phase is complete when the Software Developer has completed each prior development phase, and:
  - 1) Conducted working hands-on user interfaces demonstrations with the Owner's representative.
  - 2) Received conditional acceptance of the user interfaces from the Owner's representative.
  - 3) Final versions of this phase of Work, in electronic form, have been turned over to the Designer and the Owner's representative.
4. Phase 4 – Programming:
  - a. The Programming phase is the where the Software Developer shall write the Software to perform in accordance with the specifications and decisions made during prior Software development phases.
5. Phase 5 – Loading, Testing and Debugging:
  - a. The Loading, Testing and Debugging phase begins during, but near the end of the programming phase. During this phase, the Software shall be refined to make it fully usable by the Owner.
  - b. Software shall be loaded into the memory of applicable processors and components.
  - c. The Software shall be tested and debugged as an integral part of the complete systems being controlled. Adjustments shall be made to ensure that the Software meets the expectations of the Owner's representative.
  - d. If during this phase the Software Developer determines that the Software does not function as desired; the user interfaces do not operate in a familiar manner; the Software is unstable; or interactions with controlled equipment render the Software unstable, awkward to use, or unusable for the intended purpose, the Software Developer shall take remedial action. Should this be necessary, the Software Developer shall review the issue(s) with the Owner's representative and offer suggestions for remedial action. Acceptable remedial actions may include modifying user interfaces or adding, modifying or deleting Software features.

### **3.2 CHALLENGE RESOLUTION**

- A. If for technical reasons it is not possible to achieve a specific functionality identified in the Contract Documents or included in the storyboards, consult with the Designer and the Owner's representative to review alternative options and assist in reaching a compromise solution.

**3.3 OWNER'S MANUAL**

- A. Software Developer shall provide custom printed and editable electronic documentation containing high quality graphical representations of user interfaces.
- B. Documentation shall include descriptive text that describes the use, flow, and operation of the system from a user perspective.
- C. Documentation shall be suitable for printing, photocopying and distribution by the Owner to users of the Software.
- D. Documentation shall include information covering advanced modes, hidden buttons, and other pertinent advanced features, as well as service information that a technical person, advanced user, and/or system administrator will need for the operation, management, maintenance and expansion of the system. Information regarding these advanced features shall be included on separate pages from the documentation so that they can easily be omitted from the information duplicated by the Owner and distributed to less advanced users of the Software.

**END OF SECTION 27 4103**