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SECTION 25 4000

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for solid-state, pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA design AC motors. The term “VSD” (Variable Speed Drive) is also used in this specification.

B. Related Sections:
   1. 23 2123 - Hydronic Pumps
   2. 23 7000 - Central Air Handling Units
   3. 25 9000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:
   1. See section 20 0000 - Mechanical General Requirements.
   2. Institute of Electrical and Electronic Engineers (IEEE): IEEE 519-2014.
   3. Underwriters Laboratories (as appropriate): UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995.
   4. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA): NEMA ICS 7-2014, Adjustable Speed Drives.
   5. National Electric Code (NEC): NEC 430.120, Adjustable-Speed Drive Systems.
   6. CSA Group: CSA C22.2 No. 274.
   7. International Building Code (IBC): IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156.

1.3 SYSTEM DESCRIPTION

A. This specification is for a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.

B. The drive manufacturer shall supply the drive and all necessary options as specified. drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). Drives that are manufactured by a third party and “brand labeled” shall not be acceptable.

C. This specification is intended to supplement a drive schedule. The drive schedule identifies the optimized BOM for the project and includes quantity, size, voltage, enclosure rating, options, and harmonic mitigation requirements of the drives. IEEE 519-2014 is an electrical system standard for harmonic mitigation. Drives are a major source of harmonics, therefore the VFD manufacturer shall conduct a harmonic analysis for this particular jobsite to verify compliance with IEEE 519-2014.

1.4 PRE-INSTALLATION MEETINGS

A. See section 20 0000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See section 20 0000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Submittals shall include the following information:
   1. Outline dimensions, conduit entry locations and weights. Customer connection and power wiring diagrams.
   2. Complete technical product description with complete list of options provided. Any portions of this specification not met shall be clearly indicated or the Contractor shall be liable to provide all additional components required to meet this specification.
   3. Submit shop drawings showing specific VSD mounting arrangements. Include verification that mounting of VSD complies with IBC chapter 16 requirements.
   4. Clearly note any exceptions/deviations to this specification with the submittal.
   5. Submit information from harmonic analysis demonstrating that the drives have proper internal harmonic mitigation and will not take the system out of compliance with IEEE Standard 519. Notify the Contracting Agency if additional mitigation measures are indicated.
   6. Submit the following information:
      a. Combined harmonic content of all drives and combined harmonic content of all drives to be operated on generator.
      b. Amount of regenerated power put back into the distribution system from each drive (include drives operated on generator and drives only operated on normal power).

C. Closeout
   1. Furnish two complete sets of Installation, Operation and Maintenance Manuals and other information necessary for the operation and maintenance of the system unless otherwise noted.
   2. Submit Startup Service test results as specified under Start-up Service below.

1.6 QUALITY ASSURANCES

A. See section 20 0000 - Mechanical General Requirements.

B. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer's guidelines.

C. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).

D. The base drive shall be seismically certified per 2018 International Building Code (IBC) with a seismic importance factor of 1.5, and minimum 2.5 SDS rating.

E. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50 percent for up to 0.2 seconds, sags to 70 percent for up to 0.5 seconds, and sags to 80 percent for up to one second.

1.7 WARRANTY

A. Manufacturer Warranty: See section 20 0000 - Mechanical General Requirements, for general mechanical warranty requirements.

B. Warranty shall be 24 months from the date of certified startup. The warranty shall include all parts, labor, travel time and expenses. There shall be 24/365 support available via a toll free phone number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers are limited to the following:
   1. ABB ACH 580 Series (basis of design).
   2. Yaskawa.
   3. Siemens SED2.

2.2 VARIABLE FREQUENCY DRIVES

A. The drive package as specified herein and defined on the drive schedule shall be enclosed in a NEMA Type 12 enclosure.

B. The drive shall provide full rated output from a line of +10 percent to -15 percent of nominal voltage across an ambient temperature range of -15 to 40 degrees C (5 to 104 degrees F).

C. Drives shall utilize the same Advanced Control Panel (keypad) user interface.
   1. Plain English text:
      a. The display shall be in complete English words for programming and fault diagnostics.
      b. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch or vibration trip. Customized terms, such as: AHU-1 End Switch or CT-2 Vibration shall also be available.
   2. The control panel shall include at minimum the followings controls:
      a. Four navigation keys (Up, Down, Left, Right) and two soft keys.
      b. Hand-Off-Auto selection, Fault Reset, and manual speed control.
      c. A Help key shall include assistance for programming and troubleshooting.
   3. There shall be a built-in time clock in the control panel with 10-year battery backup.
   4. I/O Summary display with a single screen shall indicate and provide:
      a. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs.
      b. The function of all analog inputs, analog outputs, digital inputs, and relay outputs.
      c. The ability to force all inputs and outputs to either a high, low, or specific value.

5. The drive shall automatically backup parameters to the control panel. The drive shall allow two additional unique manual backup parameter sets to be stored.
6. The control panel shall be removable, capable of remote mounting.
7. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.
   a. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard.
   b. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameters.
   c. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.

D. Drives shall have the following hardware features/characteristics as standard:
1. Two (2) programmable analog inputs, two (2) programmable analog outputs, six (6) programmable digital inputs, and three (3) programmable Form-C relay outputs.
2. The drive shall include an isolated USB port for interface between the drive and a laptop.
3. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.
4. At a minimum, the drives shall have internal impedance equivalent to 5 percent to reduce the harmonics to the power line. 5 percent impedance may be from dual (positive and negative DC link) chokes, or AC line reactor. Drives with only one DC link choke shall add an AC line choke integral to the drive enclosure. Reference the required harmonic analysis to determine if additional harmonic mitigation is required for the system to comply with IEEE 519-2014.
5. The combined harmonic content of all the drives on the project shall be small enough to not interfere with an emergency generator's voltage regulator. The impact of drives capable of regeneration on applications with a generator shall be verified. On projects where drives will be operated on generator include detailed information in submittals for both of these items to allow verification of impacts on generator operation.
6. The drive shall have variable speed primary cooling fans.
7. The overload rating of the drive shall be 110 percent of its normal duty current rating for 1 minute every 10 minutes, 130 percent overload for 2 seconds every minute.
8. The input current rating of the drive shall not be greater than the output current rating.
9. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
10. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4th Edition.
11. The drive shall include a robust DC bus to provide short term power-loss ride through. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.

E. Drives shall have the following software features as standard:

1. A Fault Logger that stores the last 16 faults in non-volatile memory. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault.
3. Programmable start methods: Flying-start, Normal-start, and Brake-on-start.
4. Programmable loss-of-load (broken belt / coupling) indication. This function to include a programmable time delay to eliminate false loss-of-load indications.
5. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in "Watts."
6. There shall be a run permissive circuit for damper or valve control.
7. Four separate start interlock (safety) inputs shall be provided. The control panel will display the specific safety(s) that are open.
8. The drive shall include a switching frequency control circuit that reduces the switching frequency based on actual drive temperature. It shall be possible to set a minimum and a target switching frequency.
9. The ability to automatically restart after non-critical faults.
10. PID functionality shall be included in the drive.
11. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source.
12. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
13. The drive shall include a fireman's override mode.

F. Security Features:
   1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
   2. The drive shall include password protection against parameter changes. There shall be multiple levels of password protection including: End User, Service, Advanced, and Override.
   3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive.
   4. The "Hand" and "Off" control panel buttons shall have the option to be individually disabled (via parameter) for drives mounted in public areas.

G. Network Communications:
   1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP and LonWorks shall be available.
   2. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card-based protocol.
   3. The drive shall not require a power cycle after communication parameters have been updated.
   4. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later.

H. Disconnect:

1. A circuit breaker type disconnect shall be provided.
2. The disconnect shall be door interlocked and padlockable.
3. Drive input fusing shall be included on all packaged units that include a disconnecting means.
4. Disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

I. A manual bypass system is not desired or required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that jobsite conditions for installation meet factory-recommended and code-required conditions for VSD installation prior to start-up. These shall include as a minimum:
   1. Clearance spacing.
   2. Temperature, contamination, dust, and moisture of the environment.
   3. Conduit installation of the motor wiring and power wiring separation.

3.2 INSTALLATION

A. VSDs shall be furnished under Division 25 and installed under Division 26. The contractor shall install the drive in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.

B. Power wiring shall be provided under Division 26. The contractor shall complete wiring in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.

C. Verify that the location is ready to receive work and the dimensions are as indicated.

D. Do not install VSD until the building environment can be maintained within the service conditions required by the manufacturer. Before and during the installation, the VSD equipment shall be protected from site contaminants. The VSD shall be covered and protected from construction dust and contamination until the environment is cleaned and ready for operation. The VSD shall not be operated while the unit is covered.

E. Details of the installation shall comply with the manufacturer's applicable instructions.

F. Minimize the length of conductors between the drive and the motor to avoid motor damage from reflected wave phenomenon.

G. Mounting of VSD shall be suitable for seismic anchorage and/or restraints as required by International Building Code.

3.3 WIRING

A. Conductors feeding Variable Frequency Drives (VFDs) and between VFDs and equipment supplied by the VFDs shall be Type XHHW-2.

3.4 CONTROL WIRING

A. Control wiring and control devices shall be provided under the specification section in which the controlled equipment is specified. Coordinate related work.

B. Control wiring shall be routed completely separately from power wiring.

3.5 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VSD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

B. A computer based training CD shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VSD and serial communication.

3.6 FIELD QUALITY CONTROL

A. Start up: Certified factory startup shall be provided for each drive by a factory authorized service center. A certified startup form shall be filled out for each drive with copies submitted and included in the O&M Manuals, and a copy kept on file by the manufacturer.

B. Training: Onsite training shall be provided as part of the startup service. The training shall include installation, programming, and operation of the VSD and serial communication.

3.7 ADJUSTING

A. Coordinate hydronic and ventilation system static pressure control set points with Section 23 0593 - Testing, Adjusting and Balancing. Make necessary corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.8 CLEANING

A. Upon completion of installation and prior to initial operation, vacuum clean and wipe down VSD enclosures. Remove debris for interior of enclosures.

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SECTION 25 5000

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.

B. Related Sections: Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.
   1. 25 3000 - Building Automation System Field Devices
   2. 25 9000 - Sequence of Operations
   3. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards. Perform work in accordance with applicable national, state and local codes to include:
   1. See section 20 0000 - Mechanical General Requirements.
   2. ANSI-C2, National Electrical Safety Code - NESC.
   3. Underwriters Laboratory (UL) or approved equal.
   4. Institute of Electrical and Electronics Engineers - IEEE.
   5. National Electrical Manufacturers' Association - NEMA.

B. Abbreviations and Acronyms:
   1. Building Automation System (BAS).
   2. Direct Digital Control (DDC).

C. Definitions:
   1. ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.
   2. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135-current edition, developed under the auspices of ASHRAE.
   3. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net or domain of the same physical communication media.
   4. Building Automation System (BAS): Collection of sensors, operators, controllers, and interconnecting wiring that control the operation of the building mechanical and electrical systems as described in these specifications.
   5. Field device or field control device: A physical component such as a temperature sensor, pressure sensor, contact, motor operated valve, and motor operated damper. Generally considered to bring only one point to a controller.
   6. Gateway: A hardware/software package that allows communication between dissimilar (“foreign”) systems and different protocols. Gateways are typically custom built, configured, and used only for transmitting and receiving data between different systems. System programming through gateways is not possible within the scope of this definition.

7. LonTalk: An open protocol for communication developed privately by the Echelon Corporation in Palo Alto, California.
8. Operator workstation: The central personal computer for the user to implement day to day operation of the system.
9. Router: A device for connecting different local-area network segments within a network. Routers that are used between networks with different protocols are limited. Point mapping in this type of router is automatic and requires less than one hour to configure. This device is not capable of storing point map information.
10. TCP/IP (Transmission Control Protocol/Internet Protocol): The communication language or protocol that defines the Internet. TCP/IP can also be used as a communication protocol in private networks.
11. Terminal Unit Controller: A device to control very specific applications such as a VAV box, cabinet unit heater, fan terminal unit and the like. These units may have predefined operating sequences with limited custom programming available. (Also called an “application specific controller”).

1.3 SYSTEM DESCRIPTION

A. Design Requirements:
   1. The HVAC Control System will consist of a flat, open architecture based upon BACNet meeting the requirement of ANSI/EIA 709.1 and ASHRAE Standard 135. Provide necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
   2. The system shall operate as a low-voltage multiplexed data system. The controls and instrumentation specified herein shall be integrated and installed as a complete package by the Contractor.
   3. The completed system shall be integrated such that graphics, reports, and system interfaces from the Operators workstation appears as if there is one system.
   4. No BAS system components requiring the use of gateways will be accepted.
   5. To provide future flexibility, router domains shall not exceed nominally 75 percent of the maximum number of devices in the domain, unless specified otherwise.

B. Performance Requirements:
   1. This section specifies the requirements for the BAS to be installed in conjunction with this project.
   2. Controls contractor shall furnish and install an integrated building automation system, incorporating DDC for energy management, equipment monitoring and control, and subsystems as herein specified. Controls contractor will complete the temperature control system as specified herein.
   3. Materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Systems and components shall have been thoroughly tested and proven in actual use for at least two years.
   4. Controls contractor shall be responsible for BAS and temperature control wiring for a complete and operable system. Wiring shall be done in accordance with Divisions 26, 27 and 28 of this specification and local and national codes.
   5. Control and monitoring for mechanical systems installed under this Contract, including:
      a. Building ventilation systems.
      b. Building heating systems.

c. Boiler monitoring.

6. The Work under this Section includes furnishing and installing wiring, conduit, connectors, terminal strips, and any other equipment required to interface each sensor or control point to the control system.
7. Provide control system and subsystem network cabling, routers, and other devices required for the systems shown and specified, except as specifically noted or shown on the drawings.
8. Providing sequences of operation described in Section 25 9000 - Sequence of Operations.
9. Installation of control instrumentation and hardware specified in Section 25 3000 - Building Automation System Field Devices, necessary for a complete system of controls.
10. Integrating the controls under this Contract with the Owner's HVAC Supervisory System.
11. Commissioning support activities as required in 01 9100 - Commissioning, including requirements in development of commissioning checklists, phased commissioning, installation examination and performance test activities, training and IO&M requirements.
12. System functional requirements include, but are not limited to:
    a. BAS system shall provide all normal and off-normal control functionality without reliance upon PC file server or workstation.
    b. Programming information, graphics, databases, and other information required to restore the entire system in the event of equipment failure or malfunction or human error shall be protected with a centralized back-up system.
    c. Systems shall be designed to maximize multiple-vendor flexibility to replace or modify any portion of the system.
13. Software upgrades for PC and control network operating systems, the supervisory system, web browser, programming/binding tools, etc., without limitation shall be provided at no additional charge for a period of one year after Substantial Completion of the BAS.
14. A training program shall be provided to include: Data acquisition and report generation on the Operator’s workstation.
15. The cost of providing power from the building electrical system shall be included in the bid. Power sources are subject to submittal requirements, and review and approval.

1.4 PREINSTALLATION MEETINGS

A. Coordinate installation of the building automation system with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

1.5 SUBMITTALS

A. Refer to Section 20 0000 - Mechanical General Requirements for general submittal requirements.

B. Product Data:
    1. Provide manufacturer’s literature that demonstrates compliance with the manufacturing methods, appurtenances and salient features specified.

2. Equipment tagging method specifically listing each device and the identification tag to be applied.
3. Sequence of Operations.
4. Riser Diagrams.
5. Control Diagrams.
6. Panel layouts.
7. Valve and Damper schedules.
8. Point Summary Report.
9. Blank (Reserved for Enhanced Alarm Report).
10. Blank (Reserved for Commented PPCL).
11. Blank (Reserved for Trend Logs).
12. Blank (Reserve for Electronic Plans Room file).

C. Shop Drawings:
1. Riser Diagrams.
2. Control Diagrams.
3. Panel layouts.
4. Valve and Damper schedules.

D. Quality Control Submittals:
1. Pre-functional Installation (PC) and Functional Performance Test (FT) Checklists in accordance with Section 01 9100 - Commissioning.
2. Incorporate BAS control requirements into the applicable equipment PC/FT checklists.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

B. Operation and Maintenance Data. The O&M Manuals will consist of the following (Progression from Submittal to O&M Manual takes place using the same binders):
1. Sequence of Operations.
2. Riser Diagrams.
3. Control Diagrams.
4. Panel layouts.
5. Valve and Damper schedules.
6. Point Summary Report.
7. Enhanced Alarm Report.
8. Commented PPCL (Program Code).
9. Trend Logs.
10. Product Data including items reused from existing control system as noted.
11. Electronic Plans Room file.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts:

B. Extra Stock Materials:

C. Tools:

1.8 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturers: Companies specializing in manufacturing the products specified in this section with a minimum of three (3) years documented experience.
   2. Suppliers:
   3. Fabricators:
   4. Installers: Minimum three (3) years' experience in the installation, programming and start-up of building automaton systems.
   5. Testing Agencies: Regulatory requirements for products requiring electrical connection – Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the MOA.
   6. Licensed Professionals:

1.9 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
   1. Verify equipment and associated appurtenances are delivered in original factory packaging/crating and are free from damage and corrosion.
   2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

B. Storage and Handling Requirements:
   1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
   2. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.
   3. Replace damaged items with same item in new condition.

1.10 WARRANTY

A. Manufacturer Warranty:
   1. Provide in accordance with Section 20 0000 - General Mechanical Requirements.
   2. Provide maximum 4 hour response time to service/warranty calls from the Owner during the warranty period.

B. Special Warranty:
   1. The warranty shall consist of a commitment by controls contractor to provide, at no cost to the Owner, parts and labor as required to repair or replace such parts of the control system that prove inoperative due to defective materials or installation practices.
   2. The warranty expressly excludes routine service such as instrument calibration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

A. Siemens Building Technology (SBT).

2.2 MANAGEMENT LEVEL NETWORK (MLN).

A. Acceptable manufacturers are limited to the following:
   1. Siemens Building Technology.
   2. No Alternate Brand Request; no Substitution Request.

B. Building Level Network (BLN). Acceptable manufacturers are limited to the following:
   1. Siemens Building Technology.
   2. No Alternate Brand Request; no Substitution Request.

C. Floor Level Network (FLN). Acceptable manufacturers are limited to the following:
   1. Siemens Building Technology.
   2. No Alternate Brand Request; no Substitution Request.

2.3 APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:
   1. Application Specific Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
   2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
   3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
   4. ASC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

B. ASC Interface Software:
   1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.
   2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

C. ASC Device Software:
   1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
   2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

2.4 APPLICATION GENERIC CONTROLLER (AGC)

A. General Requirements:
   1. Application Generic Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
   2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
   3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
   4. AGC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for 'pass-thru' of signal when electronic boards are removed.

B. AGC Interface Software:
   1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.
   2. AGC shall provide a selection of control applications performable through configuration of the device. Download of new applications from network management tool shall be possible, but not required.

2.5 CUSTOM APPLICATION CONTROLLER (CAC)

A. General Requirements:
   1. Custom Application Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
   2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
   3. CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
   4. CAC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc. shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
   5. Equip CAC's with diagnostic indicators for the following:
      a. Transmit.
      b. Receive.
      c. Power up test.
      d. Power up fail.
      e. Power up test okay.

f. Bus error.

B. CAC Software:
1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.
3. Input/Output Point Processing Software shall include:
   a. Continuous update of input and output values and conditions. Connected points are to be updated at a minimum of one-second intervals.
   b. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.
   c. A reasonability check on analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
   d. Assignment of proper engineering units and status condition identifiers to analog and digital input and outputs.
   e. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
   f. Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one second increments.
4. Alarm lockouts:
   a. Alarm lockout software shall be provided to prevent nuisance alarms. on initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one minute increments.
   b. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.
   c. Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50 percent.
5. Run Time Totalization or Point Trending:
   a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile

memory and have CAC resident run time limits assignable through the operator's terminal.

b. Totalized run time or trended data shall be batch downloaded using FTP to the SS on a daily or weekly basis. Trended data shall reside on the SS database server. The automatic update of this data shall be determined by the SS and facility management application requirements.

6. Transition Counting:
   a. A transition counter shall be provided to accumulate the number of times a device has been cycled on or off.
   b. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles.
   c. Limits shall be assignable to counts to provide maintenance alarm printouts.
7. Custom Direct Digital Control (DDC) Loops:
   a. Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications.
   b. Each CAC shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:
      1). Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
      2). DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SS operator interface.
      3). The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.
      4). DDC control programs shall include an assignment of initialization values to outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

2.6 VAV CONTROLLERS

A. Provide manufacturer's thermostat matched to controller. Refer to Section 25 3000 - Building Automation System Field Devices, for requirements.

B. Coordinate with Section 23 3600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.

C. For applications requiring consistent airflow for space pressure control, provide VAV controllers with an auto-zero module to allow for periodic airflow sensor calibration without interruption of airflow.

2.7 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

A. Routers, Bridges and Repeaters:
   1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF).
   2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
   3. Routers with TCP/IP capability shall be provided where TCP/IP backbone is used.
   4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions.
   5. The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

B. Transceivers:
   1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
      a. Differential Manchester encoded signaling for polarity insensitive network wiring.
      b. Transformer isolated for common mode rejection.
      c. 78 Kbps network bit rate up to distances of 2000m.
      d. Free topology supports star, home run, multi drop and loop wiring topologies.
      e. Complies with FCC and VDE requirements.
      f. UL recognized component.
   2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
      a. Differential Manchester encoded signaling for polarity insensitive network wiring.
      b. Transformer isolation for common mode rejection.
      c. 1.25 Mbps network bit rate up to distances of 1000 meters.
      d. Unpotted construction.
      e. Less than 1 mA power consumption with +5VDC input voltage.
      f. FCC and VDE Level B requirements compliance.
      g. UL Listed.
   3. Type 3 Network Transceiver, Power Line:
      a. Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.
         1). Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
         2). Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.

3). Oversampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
4). Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.

b. The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:
1). Packaged in a rugged, potted module.
2). Programmable clock output (1.25, 2.5, 5 or 10 Mhz).
3). 10 Kbps network transmission rate.
4). Packet detect output to drive a status indicator LED.
5). Minus 20 to plus 85 degrees C. operating temperature range.
6). UL Listed.

4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications:
a. Free single-in-line package (SIP) construction.
b. Send both network data and power on a twisted wire pair.
c. Differential Manchester encoded signaling for polarity insensitive network wiring.
d. 78 Kbps network bit rate up to distances of 320 meters.
e. Supports star, home run, multidrop, and loop wiring.
f. Supplies +5VDC @ 100 mA maximum for node power.
g. Compliance with FCC and VDE requirements.
h. UL Listed.

5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:
a. 100 meter open field range.
b. Wireless communications extends network between buildings and to vehicles and portable devices.
c. FCC type certifiable, 48 MHz.
d. Low-cost miniature circuit board, SMT components.
e. Carrier detect output to drive a status indicator LED.
f. Plus 7 to plus 15VDC input voltage.
g. Minus 20 to plus 60 degrees C. operating temperature range.

2.8 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description:
1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:
a. Real-time graphical viewing and control of environment.
b. Scheduling and override of building operations.
c. Collection and analysis of historical data.
d. Point database editing, storage and downloading of controller databases.
e. Alarm reporting, routing, messaging, and acknowledgment.
f. Display dynamic data trend plot.
g. Definition and construction of dynamic color graphic displays.

h. Program editing.
i. Transfer trend data to third party software.
j. Scheduling reports.
k. Operator Activity Log.

2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.
4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
5. Scheduling and Override: Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key.
6. Collection and Analysis of Historical Data: Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

B. Dynamic Color Graphic Displays:
1. Create at least one color graphic display for each piece of mechanical equipment, including air handling units, hot water boiler systems, and room level terminal units. Provide floor plans to facilitate navigation. Point information to be displayed on the graphics shall be provided by the BAS contractor to optimize system performance and analysis and to speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of submittal AutoCAD drawings and scanned pictures for use in the system.
3. Dynamic temperature values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

6. A dynamic display of the site-specific architecture showing status of controllers, PC workstations and networks shall be provided.

C. System Configuration and Definition:
   1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
   2. Provide automatic backup and restore of DDC controller databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

D. Alarm Management:
   1. Alarm Routing shall allow the user to send alarm notification to selected PC locations based on time of day, alarm severity, or point type.
   2. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
   3. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

2.9 NETWORKING COMMUNICATIONS

A. The design of the BAS shall network an operator workstation(s) and stand-alone DDC Controllers. The network architecture shall consist of three levels; a Management Level Network (MLN) Ethernet network based on TCP/IP protocol, a high performance peer-to-peer building level network (BLN) and DDC Controller floor level local area networks (FLN). Access to the system shall be totally transparent to the user when accessing data or developing control programs.

B. Management Level Network:
   1. PCs shall simultaneously direct connect to the Ethernet and Management Level Network without the use of an interposing device.
   2. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
   3. Simultaneous user access to network limited to number of sight licenses issued to user.
   4. When appropriate, any DDC controller residing on the peer-to-peer building level network shall connect to Ethernet network without the use of a PC.
   5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet as well as directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network in addition to being able to download program changes to individual controllers.
   6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
   7. Access to the system database shall be available from any client workstation on the Management Level Network.

C. Peer-to-Peer Building Level Network (BLN):
   1. The system shall have the ability to support integration of third party systems (fire alarm, security, lighting, variable speed drives, PLCs, condensers, boilers) via a panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. Exchange points shall have full system functionality as specified herein.
   2. Data transfer via Ethernet.

D. Floor Level Network (FLN):
   1. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.10 CONTROL PANELS

A. Terminal Equipment Controllers will be mounted in enclosed control panels with screwed, removable covers.

B. Control devices located in exposed areas subject to outside weather conditions or near circulator pumps (spray due to shaft seal failures) shall be mounted inside weatherproof enclosures. Location of each panel shall be convenient for adjustment service.

C. Nameplates shall be provided beneath each panel face mounted control device describing the function of each device. Nameplates shall have white letters engraved on blue Lamicoid, or approved equal.

D. Control panels shall bear a UL label compatible with the application.

E. Electrical devices within the panel shall be pre-wired to terminal strips, with inter-device wiring within the panel completed prior to installation of the system.

F. BLN level controllers shall be provided with standby/emergency power to provide power quality and minimum 15 minutes operation.

2.11 UNINTERRUPTIBLE POWER SUPPLY

A. Acceptable manufactures are limited to the following:
   1. Powerware.
   2. Alternate Brand Request or Substitution Request required.

2.12 ACCESS PANELS

A. Access panels provided by Section 08 3100 Access Doors and Panels.

B. Coordinate access panel location with the Owner's Representative and Section 08 3100. Provide access to concealed control devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:
   1. Mount damper operators and other control devices secured to insulated ductwork on brackets such that the device is external of the insulation. See Section 20 0529 - Hangers and Supports.
   2. Do not install control devices in locations where they are subject to damage or malfunction due to normally encountered ambient temperatures.
   3. Identification: Permanently tag controllers, switches, relays, thermostats and actuators for identification using the tagging format shown on the BAS control drawings.
   4. Sensors and Switches:
      a. Pump flow or fan flow, etc., shall be sensed using current switch unless indicated otherwise. Calibrate current switch to distinguish between loaded or unloaded motor condition due to belt or coupler breakage.
      b. Protect averaging or capillary tubes where they penetrate duct with rubber grommet and seal with clear silicon. Support with capillary clips and maintain minimum 1 inch tubing bending radius.
   5. Wiring:
      a. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Install wiring in exposed or inaccessible areas in EMT conduit. Plenum-rated cable may be used in concealed, accessible areas only.
      b. Provide wiring between thermostats and unit heater motors, and control and alarm wiring.
      c. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit or plenum-rated cable.
      d. Provide conduit and control wiring for devices specified in this Section.
      e. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BAS panels located in the vicinity of motor control centers.
      f. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
      g. Wiring shall be compliant with the Divisions 26, 27 and 28 requirements and the NEC.
      h. Provide electrical wall boxes and conduit sleeves for wall-mounted devices. Mount thermostats at 54 inches AFF unless otherwise noted.
      i. Ethernet drop at or near designated BAS control panel(s), and as needed.

B. Interface with Other Work:
   1. The Contractor is responsible to furnish and install complete and operational systems. The following breakdown is recommend; carefully coordinate work between subcontractors.
   2. Products furnished by BAS contractor for installation by the mechanical contractor:
      a. Control valves.
      b. VAV box controllers.

c. Wells for hydronic temperature sensors.

3. Products furnished and installed by mechanical contractor:
   a. VAV boxes. BAS contractor shall furnish VAV box controls to the VAV box manufacturer for factory installation at the expense of the box manufacturer.
   b. VAV box controller enclosures will be provided by box manufacturer.
   c. Gauges, thermometers and thread-o-lets for BAS contractor furnished control sensor wells.
   d. Airflow measuring stations.
   e. Control and balancing dampers.
   f. Smoke and fire/smoke dampers actuators.
4. Electrical contractor (Div. 16) provides:
   a. Wiring of power feeds through disconnect starters to electrical motors.
   b. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by controls contractor.
   c. Duct smoke detectors including installation and wiring.
   d. Power wiring of smoke/fire dampers provided by Divisions 20, 21, 22, 23, 25.
   e. Stand-alone packaged controls and wiring of stand-alone packaged controls to their remote sensors and devices.
   f. Mounting and wiring of Variable Speed Drives (VSDs) furnished by the Mechanical Contractor per Divisions 20, 21, 22, 23, 25.

C. System Integration. Products to receive integration under this section:
1. Variable Speed Drives:
   a. Connect directly to the BAS through three twisted pair for Start/Stop, speed control and remote communications.
   b. Factory-furnished with the appropriate communication hardware and software to allow communication.
   c. Connections to VSD provided under this section.
2. Fire Alarm/Life Safety System:
   a. The BAS shall communicate with the fire alarm/life safety system via an alarmable point in the form of a dry contact.
   b. The device will be provided and terminated by Divisions 26, 27 and 28. This section will provide wiring to the termination device.

3.2 PROGRAMMING

A. Programming and graphics shall be included to implement the controls sequences specified in Section 25 9000 - Sequence of Operations, and to implement the systems and features included in Facility Services Divisions 20-28. It shall not be necessary for the Contracting Agency to further program the system.

B. Provide licensed copies of software tools and programming aids used to install, develop and troubleshoot the controls system to the Contracting Agency. Assist the Contracting Agency in registering the software in Contracting Agency's name.

C. Implement the control sequences for the equipment on this project as contained in Section 25 9000 - Sequence of Operations.

D. Point identifiers shall be chosen for easy identification of the actual equipment being controlled or monitored. They shall include equipment tag identifiers shown on the drawings, and may include additional characters to identify floor, area, etc. Maintain a listing of identifiers used in this project, with their plain English names. Submit the listing for review and information.

3.3 GRAPHICS

A. Graphical Mechanical Displays: Create graphical displays of major mechanical equipment for this project and install graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans derived from architectural AutoCAD representations and graphical representations of the equipment controlled under this contract.

1. Plans:
   a. Provide a central site plan for the entire facility and immediate surroundings. As a minimum indicate the following:
      1). Area designation.
      2). Number of levels on each area.
      3). Adjacent street names.
      4). North arrow.
   b. Provide floor overall floor plans for each level of the facility. As a minimum indicate the following:
      1). Area designation and level.
      2). Mechanical and electrical rooms.
      3). Control panel locations.
      4). North arrow.
   c. Provide individual floor plans for the facility. As a minimum indicate the following:
      1). Walls, doors, and general floor plan arrangement.
      2). Mechanical and electrical rooms.
      3). Temperature sensors.
      4). Temperature control zones.
      5). Control panel locations.
      6). North arrow.
      7). List of major HVAC systems serving the area including but not limited to the following:
         a) Air handling systems.
         b) Exhaust fans.
         c) Toilet exhaust fans.
         d) Heating systems.
         e) Cooling systems.
   d. As a minimum provide the following functional links on for each floor plan:
      1). Provide links back and forth between the plan screens noted above.
      2). On floor plan with temperature sensor, provide dynamic color coding for each sensor as follows:
         a) Blue indicates space temperatures less than 65 degrees F.
         b) Green indicates space temperatures between 66 degrees and 74 degrees F.
         c) Red indicates space temperatures above 75 degrees F.
      3). Provide a link to each VAV terminal unit from the associated temperature sensor.
      4). Provide a link to each major mechanical system serving the temperature sensor.
2. Room Reheat coils:
   a. Indicate the following information for each unit:
      1). Room Temperature.
      2). Coil valve position percent.

3). Fintube valve position percent.

3. Air Handling: Indicate the following information for each AHUs/MAUs, relief/exhaust fans, and toilet exhaust fans:
   a. Put control points and adjustable set points on the screen.
   b. Define action of dampers and valves (N/O or N/C);
   c. Fan schedule override commands.
   d. Reset schedules.
   e. Outside air CFM and minimum requirement.
   f. Duct static set point.
4. Building static pressure: Provide a common screen for the building and fan room static pressure sensors for the entire facility. Put control points, adjustable set points, and reset schedules on the screen.
5. Boiler Room: Indicate the following information for the heating pumps, boiler room ventilation equipment, and other boiler room equipment:
   a. Put control points and adjustable set points on the screen.
   b. Define action of dampers and valves (N/O or N/C).
   c. Pump override commands.
   d. Boiler override commands.
   e. Reset schedules.
   f. GPM flows.
   g. Outside air temperature.

B. Graphical Electrical Displays: Create graphical displays of electrical equipment specified for connection to this system. Coordinate with Divisions 26, 27 and 28 and provide graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans utilized for Graphical Mechanical Displays.
   1. Emergency/Standby Generating System:
      a. Operating parameters, generation equipment and ATS status, and alarm information.
      b. Refer to Section 26 3213 - Emergency Standby Generation System, for additional information.
   2. Power Monitoring and Control System:
      a. System alarm and status information.
      b. Refer to Section 26 0900 - Power Monitoring and Control System, for additional information.
   3. Building Lighting Control:
      a. Status information.
      b. Put control points and adjustable set points on the screen.
      c. Lighting override commands.
   4. Site Lighting Control:
      a. Status information.
      b. Put control points and adjustable set points on the screen.
      c. Lighting on/off override commands.

C. Use approved designations for room names, spaces, equipment tags, etc.

3.4 SITE QUALITY CONTROL

A. Programming BAS to provide system operation and monitoring in accordance with Section 25 9000 - Sequence of Operation and other referenced sections.

B. Trend Logs:

1. Prepare trend logs for all points required to demonstrate BAS calibration, control and stability.
2. Set points, valve positions, etc. may be temporarily adjusted to artificially induce the intended sequences to occur.

3.5 CLOSEOUT ACTIVITIES

A. Demonstration:
   1. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.
   2. The demonstration shall include, but not necessarily be limited to, the following:
      a. Review of the Trend Logs.
      b. Complete and proper operation of control systems including simulations.
      c. Access to devices for required maintenance.
      d. Review of associated graphics on Host.

B. Training:
   1. In addition, provide 8 hours of on-site instruction by BAS contractor to familiarize operating personnel with the control system. Instructions will include:
      a. A brief description of the controls' sequence of operation.
      b. A discussion and explanation of alarms, switches and gauges.
      c. A summary and explanation of steps to be taken in response to specific alarms or control malfunctions.
      d. Building walk-through to physically locate and examine control devices and demonstrate control setpoint adjustment procedures.
      e. Instructions regarding adjustment procedures shall emphasize methods for continual building "fine-tuning".

END OF SECTION 25 5000

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SECTION 25 9000

SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes the building automation system (BAS) control sequences for the heating, ventilating, and air-conditioning (HVAC) systems, electrical systems and plumbing systems provided for this project.

B. Related Sections:
1. 20 0000 - Mechanical General Requirements
2. 20 0513 - Common Motor Requirements
3. 20 0553 - Mechanical Identification
4. 21 1000 - Water Based Fire Suppression Systems
5. 22 1100 - Domestic Water Piping and Specialties
6. 22 1300 - Sanitary Waste and Vent Piping and Specialties
7. 23 0593 - Testing, Adjusting and Balancing
8. 23 1123 - Fuel Gas Piping and Specialties
9. 23 2113 - Hydronic Piping and Specialties
10. 23 2123 - Hydronic Pumps
11. 23 3100 - Ducts and Accessories
12. 23 3400 - HVAC Fans
13. 23 3600 - Air Terminal Units
14. 23 5216 - Condensing Boilers and Accessories
15. 23 6300 - Refrigerant Condensers
16. 23 7323 - Central Air Handling Units
17. 23 8200 - Terminal Heating and Cooling Units
18. 25 3000 - Building Automation System Field Devices
19. 25 4000 - Variable Speed Drives
20. 25 5000 - Building Automation System
21. Division 26 - Electrical

1.2 SUBMITTALS

A. Refer to 20 00 00 – Mechanical General Requirements.

B. Product Data:
1. Provide BAS manufacturers' product literature, clearly annotated to indicate performance criteria to include the following:
   a. Building level to floor level network controller riser diagrams. Include building locations and equipment controlled by each controller.
   b. Sequences of operation for HVAC, electrical and plumbing systems.
   c. Process control diagrams to support each sequence of operation. Show field mounted control device locations and circuit routing.
   d. Complete electrical and pneumatic BAS points list.

C. Quality Assurance/Control Submittals:
1. Installation and Functional Performance Test Letter.

a. Provide a letter certifying that the building automation system hardware is completely installed and sequences of operation have been programmed, operationally tested, with physically verification, to comply with the sequences of operation as specified. The installer(s), sub-contractor(s) and the Contractor must sign the letter.
b. Include as an attachment, a list of programming deviations from the specified sequences of operation with justification to support each deviation.
c. Include as an attachment, a table of final adjustable setpoint values for each applicable control point.

D. Installation, Operation and Maintenance Data:
1. Refer to Section 20 00 00 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
2. Provide approved submittal information, revised to reflect the actual installation as addressed in the attachments provided with the Installation and Functional Performance Test Letter, for inclusion within the project IO&M Manual.

1.3 QUALITY ASSURANCE

A. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.

B. Pre-Installation Meetings: Conduct coordination meetings, as necessary, to evaluate and coordinate the connection of the BAS to each piece of HVAC, electrical and plumbing equipment. Where the BAS is to be connected to packaged, stand-alone controllers, coordinate BAS remote control and monitoring capabilities with the specific features of the packaged controller to maximize remote operability and monitoring of each packaged controller through the BAS.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 ELECTRIC HEAT TRACE

A. Heat trace is manually controlled.

3.2 FIRE ALARM

A. Monitor the building fire alarm panel trouble and alarm status outputs.

B. On receipt of alarm, place the ventilation systems in full shutdown mode. This is a redundant shut down.

3.3 CENTRAL VENTILATION SYSTEM OVERVIEW

A. General Ventilation System Description.
1. The facilities forced air ventilation systems consist of four (4) centralized air-handling units serving the following areas:
a. AHU-1: First floor (west of Grid F).
b. AHU-2: Second floor (west of Grid F)

c. AHU-3: Central three story building area between Grids F and J, excluding Lobby 122 and Lobby 130.
d. AHU-4: Lobby 122 and Lobby 130.

B. AHU-1 and AHU-2 Ventilation Systems (Variable Air Volume, Gravity Return)
1. Both AHU-1 and AHU-2 use a similar variable air volume (VAV) control strategy incorporating variable speed drive supply fan motor controllers to modulate supply fan speed. During periods of low system demand, fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.
2. Fresh outside air is supplied through outside air intake louver (LV-1), is mixed with return air, passed through MERV 8 and MERV 14 filter elements, hydronic heating, and DX coils. Supply air leaves the AHU cabinets and is circulated to the building at 55 Degs F supply air temperature (adjustable).
3. Supply air from the AHUs is distributed their variable air volume (VAV) terminal units through systems of medium pressure ductwork. Each VAV terminal unit, with hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature (68 Degs F (adjustable)). Auxiliary perimeter hydronic finned tube heating is included for perimeter zones to improve thermal comfort.
4. Return air to AHU-1 flows by gravity back to its second floor fan room through the common return air plenum above the first floor lay-in ceiling. Return air passes directly up to the fan room through two ceiling penetrations with acoustically lined duct elbows.
5. Once in the fan room, return air either re-enters the AHU-1 mixing box to be re-circulated through the first floor spaces, or is relieved from the building through remote building relief louvers (LV-5A and LV-5B) each with motorized opposed blade relief damper located side-by-side along the exterior building wall within the first floor return air plenum.
6. The relief damper control sequence measures the pressure difference between the building exterior (ambient pressure) and the central first floor occupied area. The relief dampers modulate open and closed in parallel to maintain slightly positive building pressure (+0.05 in WC (adjustable)) within the first floor occupied spaces.
7. Similarly. return air to AHU-2 flows by gravity back to its third floor fan room through the common return air plenum located above the second floor lay-in ceiling. Return air then passes directly up to the fan room through two similar ceiling penetrations with acoustically lined duct elbows.
8. Once in the fan room, return air either re-enters the AHU-2 mixing box to be re-circulated throughout the second floor spaces, or is relieved from the fan room through relief louver (LV-2) equipped with a two position motor operated backdraft damper and variable speed mixed air flow relief fan (RF-2).
9. The RF-2 control sequence measures the differential pressure between the building exterior (ambient pressure) and the central second floor occupied area.
10. The LV-2 backdraft damper fully opens, RF-2 starts and its fan speed is modulated to maintain a slightly positive second floor building pressure (+0.05 in WC (adjustable)).
11. This is accomplished indirectly by modulating RF-2 to maintain the third floor fan room at a slightly negative pressure setpoint. The BAS continuously calculates and resets the fan room negative pressure control setpoint necessary to maintain second floor occupied space pressure setpoint.

C. AHU-3 Ventilation System (Constant Speed, Ducted Return)
   1. The AHU-3 system provides constant volume ventilation to its central building zones (3 stories).
   2. Fresh outside air is supplied through outside air intake louver (LV-1), is mixed with ducted return air, passed through MERV 8 and MERV 14 filter elements and hydronic heating and DX cooling coils.
   3. Supply air from AHU-3 is distributed at constant volume at 55 Degs F (adjustable) through a system of low pressure ductwork to zone hydronic reheat coils.
   4. Zone thermostats control reheat coil discharge temperature to maintain zone setpoint temperature (68 Degs F (adjustable)). Perimeter fin tube auxiliary heat is provided for perimeter zones to improve thermal comfort.
   5. Return air passes through a ducted return air system back to AHU-3 return/relief fan (RF-3). Return air is then either relieved from the building through roof hood (HD-2) with motor operated opposed blade building relief damper or is returned to the AHU mixing box for recirculation to the building.
   6. The HD-2 relief damper sequence measures the differential pressure between the building exterior (ambient pressure) and the central first floor building pressure. The relief damper modulates open and closed to maintain building pressure slightly positive (+0.05 in WC (adjustable)).

D. AHU-4 Ventilation System (Variable Air Volume, Single Zone)
   1. AHU-4 uses a similar variable air volume (VAV) control strategy to AHU-1 to serve the large 3 story volume Lobby 130 and connecting Lobby 122.
   2. Fresh outside air is supplied through outside air hood (HD-4), is mixed with return air, passed through MERV 8 and MERV 14 filter elements, hydronic heating and DX cooling coils. Supply air is circulated to Lobby 130 and Lobby 122 to maintain Lobby 130 zone setpoint temperature (68 Degs F (adjustable)). Auxiliary perimeter hydronic finned tube heating is included to improve thermal comfort.
   3. Reheat coil (RHC-401) is provided in the branch supply ductwork to Lobby 122 to provide additional forced air heating capacity (building entry lobby) as needed. RHC-401 is controlled by a wall mounted thermostat in Lobby 122
   4. Supply air from the AHU-4 is transferred directly to its zone through low pressure ductwork, discharging from the bottom of a continuous second story wall soffit fitted with multiple row slot diffusers.
   5. Return air is captured through a large wall grille mounted high along the west wall of Lobby 130 near the ceiling and ducted directly to the AHU-4 mixing box return air connection.
   6. Zone relief air is relieved from Lobby 130 through a single ceiling/roof mounted relief hood (HD-3) equipped with a motor operated, opposed blade building relief damper. The relief damper control sequence measures the differential pressure between the building exterior (ambient pressure) and Lobby 130. The relief damper modulates open and closed to maintain a slightly positive lobby pressure (+0.05 in WC (adjustable)).

E. General building exhaust (EF-1)
   1. EF-1 provides constant volume general exhaust ventilation for the building's centrality located restrooms and janitor closets. EF-1 operates at constant speed whenever AHU-3 is operating in Occupied Mode.

3.4 AHU-1 CENTRAL VENTILATION SYSTEM OPERATION

A. Full Shutdown Mode
   1. AHU-1
      a. Supply fan(s) off.
      b. Mixing box outside air damper fully shut.
      c. Mixing box return air damper fully open.
      d. Heating coil (HC-1) hydronic control valve shut.
      e. DX Cooling system (ACC-1) off.
   2. Building Relief
      a. Louvers (LV-5A/5B) motor operated opposed blade control dampers fully shut.
   3. Hydronic Heating System
      a. See hydronic heating system sequence of operation.
   4. DX Water Cooling System (ACC-1)
      a. See DX cooling system sequence of operations.

B. Occupied (Day) Mode
   1. AHU-1 Start Sequence
      a. Start supply fan(s).
   2. AHU-1 Supply Fan Speed Control
      a. Locate duct static pressure sensor(s) in system's main supply air duct, approximately 3/4 the distance between the AHU supply outlet and the most remote zone variable air volume (VAV) terminal unit branch duct connection. In systems with multiple supply air duct branches, provide a separate static pressure sensor in each main branch duct, in a similar arrangement.
      b. Compare branch duct pressure readings and control supply fan speed, through the variable speed drive (VSD) controller, to maintain the lowest branch pressure at +1.5 in WC set point pressure (adjustable).
   3. Building Pressure Sensing and Control
      a. Provide two (2) outdoor ambient static pressure reference heads located above the penthouse roof line on opposing corners of the building.
      b. Provide indoor ambient static pressure reference head above ceiling in **General Services 148**.
      c. Provide differential pressure analog signals to the BAS between the average of the two outdoor ambient static pressure reference heads and the indoor ambient static pressure reference head.
      d. Modulate LV-5A and LV-5B building relief dampers in parallel to maintain first floor differential building pressure setpoint (+0.05 in WC (adjustable)).
   4. AHU-1 Supply Air Temperature Control
      a. Supply the minimum outside air flow rate (CFM) as scheduled to provide the necessary outside air to both offset general building exhaust air flow rate and to maintain the building at a slightly positive building pressure (+0.05 in WC). The scheduled value meets or exceeds the minimum outside air volume required to provide acceptable indoor air quality in accordance with ASHRAE Standard 62.
      b. Measure outside air temperature (To), building return air temperature (Ti), and AHU supply-air flow rate (SA) utilizing the BAS. Calculate and update at regular intervals (15 minute, adjustable), the mixing box mixed air temperature (MAT) required to provide the minimum outside air flow rate (OSA) using the adiabatic mixing formula as follows:

(SA*MAT) = (OSA*To) + (RA*Ti) (Adiabatic mixing equation)

Assume RA = SA - OSA. Rework equation as follows:

MAT = (OSA/SA)*(To) + ((SA-OSA)/SA)*(Ti)

Where:

OSA = Minimum outside air (CFM). Constant value as scheduled.

SA equals Supply-air (CFM) as read by airflow measuring station at the fan inlet or sum of VAV terminal box supply CFMs.

RA equals return air.

To equals outside air temperature (Degrees F)

Ti equals return air temperature (Degrees F)

MAT equals the calculated mixed air temperature set point (Degrees F). Actual MAT is measure downstream of the mixing box filter bank and upstream of the AHU-1 heating coil (HC-1).

c. Modulate OSA and RA mixing box dampers in sequence to maintain calculated MAT set point at the AHU-1 MAT sensor. This establishes the minimum OSA intake requirement to meet IAQ, building pressure and exhaust air make-up requirements.
d. Provide independent outside air intake duct mounted air flow sensor to verify calculated outside air intake air flow rate (CFM). Compare with calculated value. Generate “AHU-1 IAQ” alarm is values vary by more than 10% (adjustable).
e. Measure mixing box mixed air temperature using duct averaging flexible sensors. If mixed air temperature is less than fifty-five (55) Degs F. setpoint (adjustable) shift to Heating Mode. Modulate heating coil (HC-1) hydronic control valve to maintain fifty-five (55) Degs F supply air setpoint temperature (adjustable) measured downstream of supply fan(s).
f. If mixed air temperature is greater than fifty-five (55) Degs F setpoint (adjustable), and the heating coil (HC-1)l hydronic control valve has been shut for three (3)-minutes (adjustable), shift to Economizer Cooling Mode. Modulate open outside air damper and modulate shut return air damper proportionally to maintain supply air temperature set point.
g. If mixed air temperature is greater than fifty-five (55) Degs F. setpoint (adjustable), and the outside air intake damper has been fully open for three (3)-minutes (adjustable), shift to Mechanical Cooling Mode (minimum outside air). Enable packaged DX cooling system (ACC-1) through the BAS and operate using packaged controls to maintain AHU supply air discharge temperature set point (55 Deg F (adjustable)).

C. Unoccupied (Night) Mode
1. AHU-1
a. Supply fan(s) on.
b. Mixing box outside air damper fully shut.
c. Mixing box return air damper fully open.
d. Heating coil (HC-1) hydronic control valve. See hydronic heating system sequence of operation.
e. DX Cooling system off.

2. Building Relief Louver (LV-5A/5B)
    a. Motor operated opposed blade control dampers fully shut.
    b. Building pressure control disabled.

3.5 AHU-2 CENTRAL VENTILATION SYSTEM OPERATION

A. Full Shutdown Mode
1. AHU-2
    a. Supply fan(s) off.
    b. Mixing box outside air damper fully shut.
    c. Mixing box return air damper fully open.
    d. Heating coil (HC-2) hydronic control valve shut.
    e. DX Cooling system (ACC-2) off.
2. Building Relief
    a. Louver (LV-2) motor operated parallel blade back draft damper fully shut.
    b. RF-2 off
3. Hydronic Heating System
    a. See hydronic heating system sequence of operation.
4. DX Water Cooling System (ACC-2)
    a. See DX cooling system sequence of operations.

B. Occupied (Day) Mode
1. AHU-2 Start Sequence
    a. Start supply fan(s).
2. AHU-2 Supply Fan Speed Control: See AHU-1 sequence.
3. Building Pressure Sensing and Control
    a. Use outdoor ambient static pressure reference heads: See AHU-1 sequence.
    b. Provide indoor ambient static pressure reference head above ceiling in **Admin Support Open Offices 224.**
    c. Provide differential pressure analog signals to the BAS between the average of the two outdoor ambient static pressure reference heads and the indoor ambient static pressure reference head.
    d. Fully open LV-2 back draft damper.
    e. Start RF-2 and modulate fan speed to maintain second floor differential building pressure (+0.05 in WC (adjustable)) by comparing and resetting fan room negative pressure setpoint.
4. AHU-2 Supply Air Temperature Control: See AHU-1 sequence.

C. Unoccupied (Night) Mode
1. AHU-2
    a. Supply fan(s) on.
    b. Mixing box outside air damper fully shut.
    c. Mixing box return air damper fully open.
    d. Heating coil (HC-2) hydronic control valve. See hydronic heating system sequence of operation.
    e. DX Cooling system (ACC-2) off.
2. Building Relief
    a. Louver (LV-2) motor operated backdraft damper fully shut.
    b. RF-2 off.
    c. Building pressure control disabled.

3.6 AHU-3 CENTRAL VENTILATION SYSTEM OPERATION

A. Full Shutdown Mode
   1. AHU-3
      a. Supply fan(s) off.
      b. Return/relief fan(s) off.
      c. Mixing box outside air damper fully shut.
      d. Mixing box return air damper fully open.
      e. Heating coil (HC-3) hydronic control valve shut.
      f. DX Cooling system (ACC-3) off.
   2. Exhaust Fan (EF-1)
      a. EF-1 off and associated motor operated parallel blade backdraft damper shut.
   3. Building Relief
      a. Relief Hood (HD-2) motor operated opposed blade control damper fully shut.
   4. Hydronic Heating System
      a. See hydronic heating system sequence of operation.
   5. DX Water Cooling System (ACC-3)
      a. See DX cooling system sequence of operations.

B. Occupied (Day) Mode
   1. AHU-3 Start Sequence
      a. Start supply fan(s).
      b. Start return/relief fan(s).
   2. AHU-3 Supply Fan Speed Control: See AHU-1 sequence.
   3. AHU-3 Return/Relief Fan Speed Control (as applicable)
      a. Using a return fan discharge plenum pressure sensor, modulate return/relief fan speed to maintain a constant positive +0.25 in WC static pressure (adjustable) within the return/relief fan plenum section upstream of the AHU-3 mixing box return air and building relief air control dampers.
      b. Modulate AHU-3 relief damper to maintain building pressure slightly positive (+0.05 in WC (adjustable)).
      c. Modulate AHU-3 mixing box return air (RA) damper inversely proportional to mixing box outside air (OSA) intake damper.
   4. Exhaust Fan (EF-1)
      a. Open EF-1 motor operated parallel blade backdraft damper open.
      b. Start EF-1. Operate and constant speed.
   5. Building Pressure Sensing and Control
      a. Use outdoor ambient static pressure reference heads: See AHU-1 sequence.
      b. Provide indoor ambient static pressure reference head in **Conference Room 126.**
      c. Provide differential pressure analog signals to the BAS between the average of the two outdoor ambient static pressure reference heads and the indoor ambient static pressure reference head.
      d. See AHU-3 Return/Relief Fan Speed Control sequence.
   6. AHU Supply Air Temperature Control: See AHU-1 sequence.

C. Unoccupied (Night) Mode

1. AHU-3
   a. Supply fan(s) on.
   b. Return/relief fan(s) on
   c. Mixing box outside air damper fully shut.
   d. Mixing box return air damper fully open.
   e. Heating coil (HC-3) hydronic control valve. See hydronic heating system sequence of operation.
   f. DX Cooling system (ACC-3) off.
2. Building Relief
   a. Relief Hood (HD-2) motor operated opposed blade control damper fully shut.
   b. Building pressure control disabled.
3. Exhaust Fan (EF-1)
   a. EF-1 off and associated motor operated parallel blade backdraft damper shut.

3.7 AHU-4 VENTILATION SYSTEM OPERATION

A. Full Shutdown Mode
   1. AHU-4
      a. Supply fan(s) off.
      b. Mixing box outside air damper fully shut.
      c. Mixing box return air damper fully open.
      d. Heating coil (HC-4) hydronic control valve shut.
      e. DX Cooling system (ACC-4) off.
   2. Building Relief
      a. Relief Hood (HD-3) motor operated opposed blade building relief control damper fully shut.
   3. Hydronic Heating System
      a. See hydronic heating system sequence of operation.
   4. DX Water Cooling System
      a. See DX cooling system (ACC-4) sequence of operations.

B. Occupied (Day) Mode
   1. AHU-4 Start Sequence
      a. Start supply fan(s).
   2. AHU Supply Fan Speed Control: See AHU-1 sequence.
   3. Building Pressure Sensing and Control
      a. Use outdoor ambient static pressure reference heads: See AHU-1 sequence.
      b. Provide indoor ambient static pressure reference head in **Lobby 130** at the location shown.
      c. Provide differential pressure analog signals to the BAS between the average of the two outdoor ambient static pressure reference heads and the indoor ambient static pressure reference head.
      d. Modulate HD-3 relief damper to maintain Lobby 130 differential building pressure setpoint (+0.05 in WC (adjustable)).
   4. AHU-4 Supply Air Temperature Control: See AHU-1 sequence.

C. Unoccupied (Night) Mode
   1. AHU-4
      a. Supply fan(s) on.

b. Mixing box outside air damper fully shut.
c. Mixing box return air damper fully open.
d. Heating coil (HC-4) hydronic control valve. See hydronic heating system sequence of operation.
e. DX Cooling system (ACC-4) off.

2. Building Relief
   a. Relief Hood (HD-3) motor operated opposed blade building relief control damper fully shut.
   b. Building pressure control disabled.

3.8 AHU SAFETY SHUTDOWNS

A. General
1. "Hardwire" all system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.
2. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.

B. Supply Duct Smoke Detector Shutdown:
1. Hardwire supply-duct smoke detectors directly to the building's fire alarm panel.
2. Monitor fire alarm panel "General Alarm" status from BAS system.
3. On "General Alarm" from fire alarm panel, the BAS shall:
   a. Verify air handler supply fans are off. If supply fans are operating, stop supply fans.
   b. Shut outside air intake damper (reposition return air damper to 100 percent open).
   c. Stop return/relief fans and shut relief fan damper.

C. High Duct Static Pressure Shutdown:
1. If ventilating system duct supply static pressure increases to 3.0 inches W.C. (adjustable):
   a. Command the applicable ventilating system to Full Shutdown Mode.
   b. Provide "AHU-X High Static Pressure" alarm.
   c. Provide BAS software reset to reinitiate AHU-X ventilation system restart sequence.

D. Low Temperature Shutdown:
1. If supply air temperature decreases to forty-five (45) degrees F. (adjustable):
   a. Place ventilating system in Full Shutdown Mode.
   b. Provide "AHU-X Low Temperature Shutdown" alarm.
   c. Provide BAS software reset to reinitiate AHU-X ventilation system restart sequence.

3.9 AHU MAINTENANCE AND ALARM MONITORING:

A. Air filter replacement monitoring:
1. Provide analog differential pressure sensor at each filter bank.
   a. Pre- filter (Farr 30/30 (MERV 8)) differential pressure range is 0.30 inches W.C. (clean) to 1.00 inch W.C. (dirty) at 500 feet per minute.

b. Generate "AHU-X High Pre-Filter Differential Pressure" maintenance alarm at 0.75 inch W.C. (adjustable).

2. Provide analog differential pressure sensor at each final filter bank.
   a. Final filter (Farr Riga-Flo (MERV 14) differential pressure range is 0.60 inches WC (clean) to 1.50 inches WC (dirty).
   b. Generate "AHU-X High Filter Differential Pressure" maintenance alarm at 1.00 inch WC (adjustable).

B. Zone Temperature Monitoring:
1. Generate "AHU-X Zone Temperature High/Low" maintenance alarm if any zone temperature is not being maintained within set point band tolerance as described in Day Mode and Night Mode sequences.
2. Generate "AHU-X Zone Low Temperature" critical alarm if any zone temperature falls below 55 degrees F. (adjustable).

C. Duct Static Pressure Monitoring:
1. Generate "Duct Static Pressure High/Low" maintenance alarm if duct pressure falls outside set point tolerance, plus or minus 0.05 inches W.C. (adjustable).
2. Provide three-minute alarm time delay (adjustable) to prevent spurious alarms.

D. AHU Flow Monitoring:
1. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
2. Generate "VSD Fault" alarm if the VSD fan motor controller goes into fault.

E. AHU IAQ Monitoring:
1. Monitor AHU independent outside air intake duct mounted air flow sensor.
2. Compare with calculated AHU mixing box mixed air temperature.
3. Generate “AHU-X IAQ Error” alarm is values vary by more than 10% (adjustable).

3.10 DIRECT EXPANSION (DX) COOLING SYSTEM (ACC-1 THRU ACC-4)

A. General System Description: The DX cooling system consists of four (4) separate package air cooled DX condensing units (ACC-1 thru ACC-4); one unit dedicated to each of the four (4) air handling units AHU-1 thru 4 respectively.

B. Full Shutdown Mode (Initial conditions): Condensing units (ACC-1 thru ACC-4) off.
C. Operating Mode:
1. System Enable: Enable operation of each condensing unit whenever its associated AHU is enabled in Occupied Mode and is calling for cooling.
2. Condenser Operation:
   a. Provide full modulation condenser operation using packaged microprocessor control systems to maintain DX cooling coil discharge air temperature of 55 Degs F (adjustable).
   b. If condensing unit fails, provide “ACC-X Trouble Alarm” to BAS.
3. System Shutdown: Disable operation of each condensing unit when its associated AHU is disabled.

D. System Monitoring and Alarm: Generate a separate “ACC-X Trouble Alarm” alarm following an alarm condition indicated via the gateway from a packaged condenser control panel to the BAS.

3.11 TYPICAL ZONE VAV TEMPERATURE CONTROL WITH REHEAT

A. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.

B. Occupied Mode Operation:
   1. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day set point temperature plus or minus one (1)-degree F. Reheat coil control valves remain shut.
   2. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day set point temperature plus or minus one (1)-degree F. Modulate VAV reheat coil control valve in parallel with control damper.

C. Unoccupied Mode Operation:
   1. Heating Mode: Modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night set point temperature plus zero (0), minus three (3) degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
   2. Cooling Mode: Modulate VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone unoccupied mode set point temperature plus three (3), minus zero (0) degrees F. VAV reheat coil control valve remains shut.

3.12 TYPICAL ZONE VAV TEMPERATURE CONTROL WITH REHEAT AND PERIMETER FINNED TUBE RADIATION

1. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
2. Day Mode Operation:
   a. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day set point temperature plus or minus one (1)-degree F. Reheat coil and fin tube control valves remain shut.
   b. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day set point temperature plus or minus one (1)-degree F. Modulate reheat coil and fin tube control valves in parallel with control damper.
3. Unoccupied Mode Operation:
   a. Heating Mode: Modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night set point temperature plus zero (0), minus three (3) degrees F. Modulate VAV reheat coil and fin tube control valves in parallel with control damper.
   b. Cooling Mode: Modulate VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone unoccupied mode set point temperature plus three (3), minus zero (0) degrees F. VAV reheat coil and fin tube control valves remain shut.

3.13 TYPICAL ZONE CONSTANT VOLUME (CV) TEMPEATURE CONTROL WITH REHEAT AND PERIMETER FINNED TUBE RADIATION

1. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone reheat coil control valve through the BAS.

2. Occupied Mode Operation:
   a. Cooling Mode: Reheat coil control valve remains shut.
   b. Heating Mode: Modulate reheat coil control valve to maintain zone setpoint temperature (68 Deg F (adjustable)).
3. Unoccupied Mode Operation:
   a. Cooling Mode: Reheat coil control valve remains shut.
   b. Heating Mode: Modulate reheat coil control valve to maintain zone setpoint temperature (65 Deg F (adjustable)).
4. For zones which also include perimeter finned tube radiation, modulate finned tube control valve in parallel with reheat coil control valve to maintain setpoint temperature.

3.14 GENERAL EXHAUST FAN OPERATION (EF-1)

A. Exhaust Fan EF-1 provides general building exhaust for public toilet rooms and janitor closets.
   1. Open motor operated exhaust fan backdraft damper and start exhaust fan when AHU-3 is in Occupied Mode.
   2. Stop EF-1 and shut motor operated backdraft damper during all other operating modes.
   3. Monitor exhaust fan motor operation and generate a “EF-1 Trouble” alarm if EF-1 fails to start during AHU-3 Occupied Mode operation.

3.15 BOILER ROOM 302 VENTILATION SYSTEM (SCF-1)

A. Description.
   1. Boiler Room 302 ventilation system SCF-1 provides boiler room cooling whenever necessary. Boiler (BLR-1) includes ducted/sealed combustion air allowing it to operate independently from SCF-1 operation.
   2. The SCF-1 cooling system includes a small cabinet fan with mixing box and (MERV 8) filter sections, an outside air intake louver (LV-3) and a relief air hood (HD-1) with motor operated relief damper.

B. Zone Thermostat.
   1. Provide wall mounted thermostat with output signal to BAS system.

C. Cooling Mode.
   1. Start fan SCF-1 when boiler room temperature increases above seventy-five (75) Degs F. (adjustable) setpoint temperature.
   2. Open HD-1 motor operated backdraft damper
   3. Modulate mechanically linked mixing box outside air and return air dampers to maintain 55 Deg F. supply-air discharge temperature.
   4. When mechanical room temperature falls to seventy (70) Deg F. (adjustable), stop SCF-1. Shut SCF-1 outside air damper and fully open return air damper. Shut HD-1 relief air damper.

D. Low temperature shutdown.
   1. Stop SCF-1 fan and close OSA damper if discharge supply temperature is less than forty-five (45) Deg F (adjustable). Shut HD-1 relief air damper.
   2. Provide “SCF-1 Low Temperature” alarm to BAS.
   3. Provide BAS software reset to initiate system restart sequence.

E. Minimum Run Timer. Provide ten (10) minute minimum system run time and five (5) minute minimum system off time (adjustable).

1. Smoke Detector Shutdown - Not required.

F. Filter Monitoring:
1. Provide analog differential pressure sensor across filter bank.
a. Normal filter (Camfil Farr 30/30 (MERV 8)) differential pressure range is 0.30 in WC (clean) to 1.00 in WC (dirty) at 500 feet per minute.
b. Generate "SCF-1 High Filter Differential Pressure" alarm at 0.75 in WC (adjustable).

G. Fan Monitoring: Monitor supply fan motor and generate an independent maintenance alarm if fan fails when it has been commanded “ON” by the BAS.

3.16 CENTRAL VENTILATION SYSTEM SPECIAL OPERATIONS

A. After Hours Operation.
1. Provide an operational bypass key switch with timed off (up to 2 hour duration adjustable) for each ventilation system (located as directed by the Owner) to allow manual activation of Occupied Mode Operation during times when the ventilation system would otherwise be in Unoccupied Mode.
2. Whenever the key switch is turned to the "ON" position, start the applicable ventilation system in Occupied Mode.
3. When the key switch is turned to the "OFF" position, return the ventilation system to Unoccupied Mode.
4. Wall mount and label AHU-1 through AHU-4 bypass key switches side-by-side at a location designated by the Owner.
5. Note that AHU-3 must be manually activated to operate the central toilet rooms general exhaust fan EF-1.

3.17 TELECOMMUNICATIONS/COMPUTER ROOM AIR-CONDITIONING SYSTEMS (AC-1/A/1B)

A. Operate dedicated split air conditioning system (AC-1A/1B) using package microprocessor control systems. Monitor general fault alarm through BAS.

B. See Section 23 8123 - Dedicated Air-Conditioning Units for packaged controller specific control sequences.

3.18 HYDRONIC HEATING SYSTEM OPERATION

A. General System Description.

1. The hydronic heating system consists of one full condensing hydronic boiler (BLR-1) which includes four (4) equally sized heating modules. The boiler is arranged in a primary/secondary piping arrangement. Each boiler heating module includes a dedicated primary heating loop circulator pump within the boiler cabinet.

2. Redundant secondary building heating loop variable speed pumps (PMP-1/2), provide circulation to terminal devices and to the glycol heating loop heat exchanger (HX-1).

3. The glycol heating loop (HX-1 and PMP-3/4) serves the air handling unit heating coils (HC-1 thru HC-4) to provide freeze protection.

B. Coordination with Packaged Boiler Controls.

1. Provide BLR-1 with packaged controls and field installed hydronic system sensors such that BLR-1 can operate the hydronic heating system independent of the BAS in the event of a BAS system (and during construction prior to the BAS system becoming operational).
2. Fully coordinate connection of the BAS to the packaged boiler control system.
3. Provide boiler enable/disable and secondary building heating loop temperature reset through the BAS.

C. Full Shutdown Mode (Initial conditions).

1. Boiler (BLR-1) off.
2. Primary BLR-1 circulator pumps off.
3. Secondary heating loop circulator pumps off (PMP-1/2).
4. Heat exchanger (HX-1) primary side two-way control valve open.
5. Glycol heating loop circulator pumps off (PMP-3/4)
6. HC-1, HC-2 two-way control valves shut.
7. HC-3 three-way control valve in full bypass
8. HC-4 two-way control valves shut. Rc
9. Recirculation pump (PMP-5) off.

D. Operating Mode.

1. System Enable
    a. Manual Mode: Provide three-position on/off/auto switch located on BLR-1 control panel to allow local manual enable, disable or automatic BLR-1 control from the BAS (normal condition).
2. System Start-up
    a. Start lead secondary loop circulator pump (PMP-1 or PMP-2). Operate secondary circulator pumps with lead pump in “run” and standby pump in “standby.” If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.
    b. After secondary loop flow has been established for 5 minutes (adjustable), enable boiler operation.
    c. Provide lead/lag control for secondary building loop circulators (PMP-1/2). Alternate lead loop pump monthly (adjustable) during the heating season.
3. Boiler Operation

a. Enable boiler from the BAS and operate the boilers using packaged boiler controls in accordance with the manufacturer's suggested operating instructions to maintain secondary loop supply temperature.

b. Calculate "secondary building loop water temperature setpoint" in accordance with the following linear reset schedule:

Hydronic System Temperature Reset Schedule	
Outside Air Temperature	Secondary Loop Water Temperature Setpoint
60 Degrees F.	120 Degrees F.
0 Degrees F.	180 Degrees F.

c. Compare actual secondary loop temperature (sensor located downstream of air separator AS-1) with computed secondary loop water temperature as determined by reset schedule.

4. System Shutdown.

a. Initiate Full Shutdown Mode in the following events:

1). Manual disable (Off) mode.

2). Low water cutoff shutdown.

E. Variable Speed Hydronic Pump Control (PMP-1/2).

1. Provide a separate hydronic system pressure sensor in each main hydronic header branch line. Locate sensor approximately 3/4 the distance between the secondary loop circulator pump (PMP-1/2) discharge and the most remote terminal heating unit control valve in each branch.

2. Adjust VSD controller output to modulate pump speed between thirty-five (35) percent and one hundred (100) percent flow to maintain the lowest reading hydronic header pressure sensor at setpoint pressure. Set initial header pressure setpoint to five (5) PSIG (adjustable).

3. Program the VSD bypass mode so that the pump operates at one hundred (100) percent speed in the event of VSD failure.

4. Provide manual override of VSD system. Pump operates at eighty (80) percent speed during manual override mode.

F. Glycol Heating Loop

1. The glycol heating loop provides freeze protection for AHU-1 through AHU-4 heating coils (HC-1 through HC-4 respectively).
2. When AHU-1 through AHU-3 supply air temperature drops below set point temperature and its respective heating coil control valve starts to open, start lead glycol loop circulator pump (PMP-3 or PMP-4). If lead pump fails to start as determined by current sensor, disable the lead pump and start then standby pump. Modulate heating coil control valve to maintain AHU supply temperature set point.
3. Note that AHU-4 includes a HC-4 circulation pump (PMP-5). When AHU-4 supply air temperature drops below setpoint temperature, start HC-4 recirculation pump

(PMP-5). When its heating coil two-way control valve starts to open, start lead glycol loop circulator pump (PMP-3 or PMP-4). If lead pump fails to start as determined by current sensor, disable the lead pump and start then standby pump. Modulate heating control valve to maintain AHU-4 supply temperature set point.

4. Heat exchanger (HX-1) primary (water side) two-way control valve (normally open), modulates shut to maintain glycol loop supply glycol temperature 10 Deg F (adjustable) below secondary building heating loop supply reset temperature setpoint.

G. Hydronic System Monitoring and Alarm.

1. Boiler safeguard alarms (BLR-1).
    a. Generate a “BLR-1 Shutdown” alarm BLR-1 is shut down by its packaged controls.
2. Secondary building heating loop pump trouble alarms (PMP-1/2).
    a. Provide current sensing (digital) for each pump.
    b. Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:
        1). Both pumps are off when OSA temperature is below System and Pump Setpoint).
        2). Lead pump fails to operate and system switches to lag pump.
        3). Both pumps are running.
3. Glycol heating loop pump trouble alarms (PMP-4/5):
    a. Provide current sensing (digital) for each pump.
    b. Generate an alarm if pumps fail to operate in their normal sequence, if lead pump fails to operate and system switches to lag pump, both pumps are running.
4. AHU-4 heating coil recirculation pump trouble alarm (PMP-5).
    a. Provide current sensing (analog) for pump.
    b. Generate an alarm if PMP-5 fails to operate when commanded ON through the BAS.
5. Hydronic System Low Pressure Alarms.
    a. Monitor both the secondary building heating loop and the glycol heating loop system pressures independently with analog pressure sensors.
    b. Generate a “Building Heating Loop Low Pressure” alarm if the secondary building heating loop pressure falls below ten (12) PSIG (adjustable).
    c. Generate a “Glycol Heating Loop Low Pressure” alarm if the glycol heating loop pressure falls below ten (12) PSIG (adjustable).

3.19 HYDRONIC HEATING SYSTEM TERMINAL HEATING DEVICES

A. Air Handling Unit Heating Coils (HC-1 through HC-4).
   1. See ventilation system control sequences.

B. Zone VAV Terminal Reheat Coils (VAV -1 through VAV-114 and VAV-201 through VAV-220).
   1. See ventilation system control sequences.

C. Zone Reheat Coils (RHC-301 through RHC-308 and RHC-401).
   1. See ventilation system control sequences.

D. Cabinet Unit Heater (CUH-1).
   1. At 65 degrees F. (adjustable) and decreasing, start fan and open two-way hydronic control valve.
   2. At 68 degrees F. (adjustable) and increasing, stop fan and shut two-way hydronic control valve.

E. Unit Heaters (UH-1/2/3/4).
   1. At 65 degrees F. (adjustable) and decreasing, start fan and open two-way hydronic control valve.
   2. At 68 degrees F. (adjustable) and increasing, stop fan and shut two-way hydronic control valve.

3.20 PLUMBING

A. Domestic Electric Water Heater (WH-1).
   1. Utilize packaged water heater controls.
   2. Set supply temperature aquastat to 120 Deg F. (adjustable).

B. Domestic Point of Use Water Heater (WH-2).
   1. Utilize packaged water heater controls.
   2. Set supply temperature aquastat to 105 Deg F. (adjustable).

C. Hot Water Circulation Pump (PMP-6): Provide scheduled time-of-day operation for the domestic hot water recirculation pump:
      a. Pump start: 0600 (adjustable).
      b. Pump stop: 2200 (adjustable).

D. Water Meter Monitoring.
   1. Provide water meter totalizing to the BAS.
   2. Generate a BAS alarm if daily water consumption exceeds 500 gallons/day (adjustable).

3.21 BUILDING ENERGY USE MONITORING

A. Digital Energy Monitor (DEM)
   1. Self-contained microprocessor based power transducer with three (3) phase, split core current transformers (CTs) for main distribution panel (MDP).
   2. Directly connectable to Apogee floor level network (FLN).
   3. See Power One-Line Diagram for MDP service size (2500-amp service).

4. Manufacturer: Siemens, DEM Series 2000

B. Fuel Gas Meter Pulser
   1. Magnetically actuated reed switch mounted in polycarbonate housing design for installation on commercial/industrial gas meters.
   2. Connect to BAS to totalize natural gas fuel usage.
   3. Manufacturer: Miners & Pisani, Inc., Model: MVP-10

C. Provide BAS graphical and spreadsheet output display of the buildings electrical and thermal energy usage (e.g. KW, KWD, KVA and BTU usage on hourly basis) utilizing the DEM and gas meter pulser. Include total building electrical energy usage as sensed from the MDP DEM.

END OF SECTION 25 9000

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SECTION 26 0000

ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this Section.

B. This section describes specific requirements, products, and methods of execution, which are typical throughout the electrical work of this project. Additional requirements for the specific systems may modify these requirements.

C. This Section applies to all Divisions 26 and 27 and is part of all other Divisions 26 and 27 Sections.

D. Index of Electrical Specifications:
1. 26 0000 - Electrical General Requirements
2. 26 0519 - Low Voltage Electrical Power Conductors and Cables
3. 26 0526 - Grounding and Bonding for Electrical Systems
4. 26 0529 - Hangers and Supports for Electrical Systems
5. 26 0533 - Raceway and Boxes for Electrical Systems
6. 26 0553 - Identification for Electrical Systems
7. 26 0919 - Enclosed Contactors
8. 26 2416 - Panelboards
9. 26 2726 - Wiring Devices
10. 26 2800 - Low Voltage Circuit Protective Devices
11. 26 2816 - Enclosed Switches and Circuit Breakers
12. 26 2900 - Low Voltage Controllers
13. 26 5000 - Lighting Fixtures
14. 27 2010 - Telecom Distribution System

1.2 REFERENCES

A. Codes: Perform work in strict accordance with applicable national, state and local codes; including, but not limited to the latest legally enacted editions of the following specifically noted requirements:
1. NFPA 70, National Electrical Code - NEC.
2. ANSI-C2, National Electrical Safety Code - NESC.
3. International Building Code - IBC.
4. International Fire Code - IFC.
5. Underwriters Laboratory (UL) or approved equal.

B. Standards: Reference to the following standards infers that installation, equipment and material shall be within the limits for which it was designed, tested and approved, in conformance with the current publications and standards of the following organizations:
1. American National Standards Institute - ANSI.
2. American Society for Testing and Materials - ASTM.

3. American Society of Heating Refrigerating and Air Conditioning Engineers - ASHRAE.
4. Institute of Electrical and Electronics Engineers - IEEE.
5. Insulated Cable Engineers Association - ICEA.
6. National Electrical Manufacturers' Association - NEMA.
7. National Fire Protection Association - NFPA.

1.3 DEFINITIONS

A. "Accessible" means arranged so that an appropriately dressed man, 6 feet-2 inches tall, weighing 250 pounds, may approach the area in question with the tools and products necessary for the work intended and may then position himself to properly and safely perform the task to be accomplished, without disassembly or damage to the surrounding installation.

B. "Authority Having Jurisdiction" is the individual official, board, department, or agency established and authorized by the political subdivision created by law to administer and enforce the provisions of the Code as adopted or amended.

C. "As Specified" denotes a product, system, or installation that:
   1. Includes all of the salient characteristics identified in the Drawings and Specifications;
   2. Meets all of the requirements of the "Basis of Design"; and
   3. Is produced by a manufacturer listed as acceptable on the Drawings or in the Specifications.

D. "Basis of Design" refers to products around which the design was prepared. Some or all of the particular characteristics of Basis of Design products may be critical to the fit or performance of the completed installation. Such characteristics are often subtle. Where substitutions are made to products that are the Basis of Design, the Contractor is alerted that nominally acceptable substitutions may produce undesirable side effects such as switchboards that no longer fit the space due to increased product dimensions. The Contractor is responsible for resolving all impacts of substitutions. Approval of a substitution request does not relieve the Contractor of complying with the design intent and all Codes.

E. "Contracting Agency" is the Owner as defined in the General Conditions of the Contract.

F. "Demolish" means to permanently remove a component, equipment, or system and it's appurtenances with no intent for reuse and to properly dispose of it.

G. "Furnish" means to purchase material as shown and specified, and cart the material to an approved location at the site or elsewhere as noted or agreed to be installed by supporting crafts.

H. "Install" means to set in place and connect, ready for use and in complete and properly operating finished condition, material that has been furnished.

I. "Product" is a generic term that includes materials, equipment, fixtures and any physical item used on the project.

J. "Provide" means furnish all products, labor, subcontracts, and appurtenances required and install to a complete and properly operating, finished condition.

K. “Remove” means to remove a component, equipment, or system and it's appurtenances and either store it for re-installation, reuse, or turn it over to the Contracting Agency.

L. "Rough-in and Connect" means provide an appropriate system connection such as conduit with junction boxes, wiring, switches, disconnects, etc., and wiring connections. Equipment furnished is received, uncrated, assembled, and set in place under the Division in which it is specified.

M. "Serviceable" means arranged so that the component or product in question may be properly removed, and replaced without disassembly, destruction or damage to the surrounding installation. "Serviceable" components shall be "accessible".

N. "Shop Drawings" are dimensioned working construction drawings drawn to scale to show an entire area of work in sufficient detail to demonstrate service and maintenance clearances and complete coordination of all trades.

O. "Substitution" is a product, system or installation that is not by a listed manufacturer or does not conform to all salient characteristics identified in the Contract Documents, but which the Contractor warrants meets all specific requirements listed in the Contract Documents.

P. "System Drawing" is a diagrammatic engineered drawing that shows the interconnection and relationship between products to demonstrate how the products interact to accomplish the function intended. Examples of system drawings include control and instrumentation diagrams, and wiring diagrams. Some drawings, such as dimensioned and complete Fire Suppression Drawings may be both System Drawings and Shop Drawings.

1.4 PERFORMANCE REQUIREMENTS

A. Provide labor, products and services required for the complete installation, checkout and startup of electrical systems shown and specified. Where the work of several crafts is involved, coordinate related work to provide each system in complete and in proper operating order.

B. Lay out the work in advance and avoid conflict with other work in progress. Physical dimensions shall be determined from existing conditions. Verify locations for junction boxes; disconnect switches, stub-ups, etc., for connection to equipment furnished by others, or in other Divisions of this Work.

C. Refer to the “Suggested Coordination Schedule” in Section 20 0000 - Mechanical General Requirements.

D. Cooperate with others involved in the project, with due regard to their work, to promote rapid completion of the entire project.

E. Coordinate installation of panels, equipment, system components, and other products to provide proper service areas and access for items requiring periodic maintenance inspection or replacement.

F. Reference to a specific manufacturer's product (even as "Basis of Design") does not necessarily establish acceptability of that product without regard to compliance with all other provisions of these specifications.

G. Local Conditions: The Contractor shall thoroughly familiarize himself with the work as well as the local conditions under which the work is to be performed. Schedule work with regard to seasons, weather, climatic conditions and other local conditions which may affect the progress and quality of the work.

H. Demolition: Coordinate related demolition in support of the project. Restore circuits and systems, which are to remain, but which are affected in any way by demolition Work. Conduct a site visit prior to bid to determine Scope. Refer to Part 3 of this Section for execution requirements.

1.5 SUBMITTALS

A. Refer to Division 1 for general submittal, closeout submittal and product substitution requirements. In addition, prepare Divisions 26 and 27 submittals in accordance with the following.

B. Specification section drawings, calculations, and products shall be complete and submitted together in one package.

C. General:
1. The Contracting Agency's obligation to review submittals and to return them in a timely manner is conditioned upon the prior review and approval of the submittals by the Contractor as required by the Construction Contract.
2. Streamlining: in many instances, the products, reference standards, and other itemized specifications have been listed without verbiage. In these cases, it is implied that the Contractor shall provide the products and perform in accordance with the references listed.
3. Submittal review is for general design and arrangement only and does not relieve the Contractor from any of the requirements of the Contract Documents.
4. Submittals will not be checked for quantity.
5. Submittals will not be exhaustively checked for dimension or fit, or for proper technical design of manufactured equipment. Provision of a complete and satisfactory working installation is the responsibility of the Contractor.
6. Furnish suppliers with the applicable portions of the Contract Documents and review and verify that the suppliers' submittals clearly represent products which comply with the Contract Documents.

D. Electronic Submittals:
1. Submittals may be in electronic (PDF) format.
   a. Electronic submittals shall follow the organization and formatting required for paper submittals.
      1). Provide electronic bookmarks within the PDF document in place of tabs and sub-tabs.

2). If individual PDF files are provided for each product or shop drawing sheet, organize files into folders and name files and folders to correspond with applicable specification sections or drawing titles.

b. If submittal is a scanned document, run the optical character recognition OCR function to ensure the document is searchable and can be copied and pasted.

c. Electronic submittals may be transmitted via Email, disc or download from a project or construction Website.

E. Coordination:

1. Create and maintain a master submittal log for all items submitted in Divisions 26 and 27
2. Prior to submission for approval hold a meeting of all trades to review all shop drawings and submittals. All trades shall cross-check all shop drawings and submittals for conflicts, clearances, physical space allocation and routing, discrepancies, dimensional errors, omissions, contradictions, departures from the Contract requirements, correct electrical/mechanical services and connections, and provisions for commissioning.
3. Revise, correct, and appropriately annotate submittals prior to submission for approval.
4. A current copy of approved submittals and the submittal log shall be kept at the job site.

F. Product Submittals

1. General: This section describes in detail the preparation of electrical product submittals. Submittals not provided as described shall be rejected without review. This procedure is designed to accelerate and improve the accuracy of the technical review process, as well as, simplify the preparation of the Installation, Operation, and Maintenance Manuals (IO&Ms) during project closeout.
2. Submittal Organization:
   a. Organize product submittal information in the same order as the products are specified to simplify the technical review process. Provide a separate tabbed divider for each Divisions 26 and 27 specification section. Provide the typed section number on each tab.
   b. Within each section, organize the product information in the same order as the products are specified in Part 2 of each applicable specification section. Provide sub-tabs within each section for each separate product article. Provide the typed product article number on each tab.
   c. Provide product submittal information for each product specified in 8-1/2" x 11" format. Fold-out 11" x 17" format is also acceptable.
   d. If a particular specified product is being omitted from the product submittal or will not be used for the project, provide a single sheet within the article tab identifying the product and annotated with a brief reason why the product is not being submitted, for example: "NOT USED," NO SUBMITTAL REQUIRED," "TO BE SUBMITTED BY (PROVIDE DATE)," etc. This will inform the reviewer that the product was not overlooked.
   e. Partial submittals from individual subcontractors may be provided which cover a particular sub-contractor's scope of work. In this case, arrange partial submittals by system classification such as: LIGHTING, POWER DISTRIBUTION, FIRE ALARM, ACCESS CONTROL SYSTEM, etc. Within each system classification, arrange product submittals by specification

section, as described, such that each specification section can easily be reorganized into a master set of Divisions 26 and 27 product submittals organized by specification section. This will greatly simplify the preparation of IO&M manuals as described below.

f. Bind product submittal information in 3 inch wide, hard backed, loose leaf, 3 ring binders with clear front and spine insert pockets. Divide information into multiple volumes such that the pages in each binder rest naturally on one side of rings.
g. Provide a master table of contents at the front of each volume which lists the Divisions 26 and 27 specification sections and indicates which sections are located within each volume.
h. Provide a table of contents within each section which lists the Part 2 products for that section in the same order as the applicable specification section.
i. Provide identical cover and spine inserts for each product submittal volume.
j. For multiple volumes, label each volume. Include the following typed information on the front cover and spine inserts of each volume:
   1). The Contracting Agency Name
   2). Project Name
   3). Contractor Name
   4). Subcontractor Name preparing the submittal.
   5). Date that the submittal or resubmittal was initiated.
   6). “Electrical Product Submittals”, etc. as appropriate.
   7). “Volume 1 of X, Volume 2 of X,” etc.

3. Product Information:
   a. Indicate manufacturer's name and address, and local supplier's name, address, phone number.
   b. Indicate each product as “Basis of Design”, “As Specified” or as “Proposed Substitution.”
   c. Identify Catalog designation and/or model number.
   d. Neatly annotate each salient characteristic and design options of the product to demonstrate compliance with the Contract Documents to include: Scheduled information, drawing information and specified information. Clearly indicate product deviations from the Contract Documents and mark out non-applicable items on generic “cut-sheets.”
   e. Include manufacturer provided dimensioned equipment drawings with mechanical and electrical rough-in connections.
   f. Include operation characteristics, performance curves and rated capacities.
   g. Include motor characteristics and wiring diagrams for the specific system.
   h. Provide basic manufacturer’s installation instructions.
4. Provide coordination data to check protective devices.
5. Provide information required to verify compliance with the short circuit withstand and interrupting ratings, as shown on the Drawings or further stated in these Specifications.
6. Provide certification that all data shown on the Drawings or further stated in these Specifications concerning available short-circuit currents has been confirmed with the serving Electric Utility.
7. Product Substitutions:
   a. Clearly indicate both in the section table of contents and on the individual product submittal information each proposed substitution, deviation or change from the product as described in the Contract Documents.

b. Submittal approval does not include substitutions, deviations or changes from the requirements of the Contract Documents unless they are specifically itemized and approved. The term “No Exceptions Taken” will not apply to substitutions, deviations or changes not clearly identified.
c. Provision of a satisfactory working installation of equal quality to the system as described in the Contract Documents shall be the responsibility of the Contractor.
d. Correct unapproved deviations from the Contract Documents discovered in the field as directed by the Contracting Agency at no additional cost to the Owner.

G. System Drawings:
1. Submit System Drawings for dynamic elements/systems of the project which are performance specified to include but not limited to: Fire Alarm Systems, Lightning Protection Systems and stand-alone packaged equipment.
2. Prepare system drawings on full sized sheets of the same size as the original construction drawings.
3. Include with each system a sequence of operation narrative which describes each mode of system operation in sufficient detail to demonstrate compliance with the Contract Documents to the satisfaction of the Contracting Agency.

H. Shop Drawings:
1. General:
a. The Contract Documents are not intended for nor are they suitable for use as shop drawings. Do not use Contract Drawings for direct fabrication or installation of products or equipment.
b. Divisions 26 and 27 products and systems shall not be installed without shop drawings approved by the Contracting Agency.
c. Rework, changes or additional engineering support required as a result of the installation of products and systems prior to the approval of applicable shop drawings by the Contracting Agency shall be provided at the Contractor’s expense.
2. Preparation:
a. Review each Divisions 26 and 27 specification section and identify the project’s shop drawing requirements.
b. Prepare shop drawings on full sized sheets of the same size as the original construction drawings.
c. Arrange shop drawings to scale, showing dimensions where accuracy of location is necessary for coordination or communication purposes.
d. Incorporate the actual dimensions and configurations of the products and systems approved through the product submittal process into the shop drawings.
e. Provide dimensioned maintenance clearance areas around each product as recommended by the manufacturer.
f. Meet with and coordinate Divisions 26 and 27 work with the interrelated work of other trades including Architectural, Civil, Structural, and Mechanical to identify and resolve potential conflicts.
g. Clearly identify and provide recommendations to resolve major conflicts which may impact the design of the systems as shown. Resolve such conflicts during the shop drawing review process.

h. In cases where one or more equipment items in a mechanical or electrical room or space differ in dimensions or configuration from Basis of Design equipment, the working drawing shall show the entire area. The drawing shall be dimensioned to indicate that required aisle ways and maintenance clearances are being maintained to at least the degree shown on the Contract Drawings.
i. Provide shop drawings for all products, systems, system components, and special supports that are not a standard catalog product and which may be fabricated for the Contractor or by the Contractor. In addition provide shop drawings for:
   1). Electrical and telecommunications rooms and spaces, including all equipment. Demonstrate all required clearances and working spaces are provided.
   2). Routing and interdisciplinary coordination of groups of conduits numbering more than one and over two inch trade size.
   3). Busways.
   4). Cable Trays.
   5). Floor ducts.
   6). Telecom equipment rack elevations.
   7). CCTV equipment rack elevations.
   8). Where noted on the drawings.
   9). Where noted in other Divisions 26 and 27 sections.

3. Shop Drawing Submittal:
   a. Submit dimensioned shop drawings as specified to demonstrate proper planning and sequencing of the applicable trades for the installation and arrangement of Divisions 26 and 27 with respect to other interrelated work.
   b. Installation conflicts arising from the failure to properly coordinate the work of related trades shall be resolved at the Contractor's expense.

I. Record Drawings
1. General: As the Work progresses, neatly annotate a designated and otherwise unused, set of Divisions 26 and 27 Contract Drawings to show the actual locations and routing of Divisions 26 and 27 Work and the terminal connection points to related Work. As a minimum, include the following:
   a. Annotate record drawings to incorporate each applicable addendum.
   b. Annotate record drawings as directed by each applicable Request for Information (RFI) and accepted Change Order Proposal.
   c. Modify record drawings to show actual equipment sizes and locations.
   d. Provide fully dimensioned locations for permanently concealed conduits (i.e. conduit cast in concrete or buried underground/underslab).
   e. Show routing of work in permanently concealed blind spaces within the building.
   f. Maintain drawings in an up-to-date fashion in conjunction with the actual progress of installation. Accurate progress mark-ups shall be available on-site for examination by the Contracting Agency or his representative at all times.
2. Preparation:
   a. Neatly annotate record drawings to provide clear interpretation to support electronic drafting by a third party.
   b. Tape electronic sketches from addendums and/or RFIs directly to the record drawings as overlays.

c. Annotate the record drawings in colored pencil using the same symbols and abbreviations as indicated in the Divisions 26 and 27 legends and schedules of the Contract Drawings.
   1). Red to add information.
   2). Green to delete information.
   3). Blue to provide additional clarifying information which is not to be drafted.
d. After submittal to the Contracting Agency, provide additional clarification, information or rework as necessary to support the accurate interpretation and electronic drafting of the record drawings.

3. Submittals:
   a. Provide dimensioned underslab record drawings to the Contracting Agency prior to pouring the slab. For slabs poured in multiple sections, provide record drawings for the applicable slab sections to the Contracting Agency prior to each pour.
   b. Provide complete record drawings for concealed areas (i.e. above lay-in and hard ceilings and inside walls) to the Contracting Agency prior to concealment.
   c. Provide the remaining portion of the record drawings for exposed areas to the Contracting Agency prior to the final completion of the project.
   d. Prepare wiring diagrams on reproducible media for individual special systems as installed. Identify components and show wire and terminal numbers and connections. Include diagrams from the shop drawings and submittals, updated to show as-built condition.

J. Test Certificates:
   1. Review the submittal requirements for Quality Assurance/Control Submittals for each specification section.
   2. Submit copies of design data, test reports, certificates, manufacturer's instructions and field test reports as specified. This information may be included within the Operations and Maintenance (IO&M) Manuals as determined by the Contracting Agency.

K. Operations and Maintenance (IO&M) Manuals:
   1. Provide specific product IO&M information for each section as detailed within each Divisions 26 and 27 section.
   2. Begin the preparation of the electrical Operation and Maintenance Manuals with a complete and fully approved set of electrical product submittals organized, annotated and with the product information as indicated within the "Product Submittals" article for each specification section.
   3. Next, augment each individual product submittal with the written installation, operations and maintenance information for each specific product. Obviously, this type of information is not applicable (or available) for bulk commodity or simplistic products such as conduit or equipment tags, etc.
   4. Maintenance information shall include:
      a. Preventive maintenance requirements for each product, including the recommended frequency of performance of each preventive maintenance task.
      b. Instructions for troubleshooting, minor repair and adjustments required for preventive maintenance routines, limited to repairs and adjustments that

may be performed without special tools or test equipment and that require no extensive special training or skills.
   c. Information of a maintenance nature covering warranty items, etc., that have not been discussed in the manufacturers' literature.
   d. Information data for spare and replacement parts for each product and system. Properly identify each part by part number and manufacturer.
   e. Recommended spare parts list.
5. Organize the Operation and Maintenance Manual information by specification section (not by sub-contractor) with a tabbed divider separating each section. Provide the typed section number on each tab.
6. Within each section, organize the product information in the same order as the products are specified in Part 2 of each applicable section. Provide sub-tabs within each section for each product. Provide the typed product article number on each tab.
7. Bind the information in identical, 3 inch wide; hard backed loose leaf 3 ring binders with clear front and spine insert pockets. Divide information into multiple volumes so that the pages in each binder rest naturally on one side of rings.
8. Provide a master table of contents at the front of each volume which lists the Divisions 26 and 27 specification sections and indicates which sections are located within each volume.
9. Provide a table of contents within each section which lists the Part 2 products for that section in the same order as the applicable specification section.
10. Provide identical cover and spine inserts for each IO&M manual volume.
11. For multiple volumes, label each volume.
12. Include the following typed information on the front cover and spine inserts of each volume:
   a. The Contracting Agency Name.
   b. Project Name.
   c. "Electrical Operations and Maintenance Manual".
   d. "Volume 1 of X, Volume 2 of X," etc.
13. Submit copies of all Operation and Maintenance Manuals in electronic format (Adobe PDF).

1.6 QUALITY ASSURANCE

A. Qualifications: Perform the Work using qualified workmen that are experienced and usually employed in the trade.

B. Product Testing and Certification:
   1. Nationally Recognized Testing Laboratory (NRTL) Labeling: Electrical equipment and conductors shall be "Approved," "Certified," "Identified," or "Listed" and "Labeled" to establish that the electrical equipment is safe, free of electrical shock and fire hazard, and suitable for the purpose for which it is intended to be used. The manufacturer shall have the specific authorization of one of the Occupational Safety and Health Administration (OSHA) approved Nationally Recognized Testing Laboratories (NRTLs) in accordance with the applicable national standards to label the equipment as suitable.
   2. Further details on the specific NRTLs, as well as the product standards that they are specifically recognized to evaluate equipment in accordance with, can be found on the OSHA Web site: http://www.osha.gov/dts/otpca/nrtl/

C. Drawings and Specifications:
   1. The Drawings and specifications are complementary. Do not scale the Drawings. Locations of devices, fixtures, and equipment are approximate unless dimensioned.
   2. The Drawings are partly diagrammatic and do not show precise routing of conduits or exact location of all products, and may not show in minute detail all features of the installation; however, provide all systems complete and in proper operating order.
   3. Drawing symbols used for basic materials, equipment and methods are commonly used by the industry. Special items are identified by a supplementary list of graphical illustrations, or called for on the Drawings or in the specifications.

D. Tests and Inspections:
   1. Schedule, obtain, and pay for permits and fees required by local authorities and by these specifications.
   2. Request for Tests: Notify the Contracting Agency a minimum of 24 hours in advance of tests. In the event the Contracting Agency does not witness the test, certify in writing that all specified tests have been made in accordance with the specifications.
   3. Deficiencies: Immediately correct deficiencies that are evidenced during the tests and repeat tests until system is approved. Do not cover or conceal electrical installations until satisfactory tests are made and approved.
   4. Operating Tests: Upon request from the Contracting Agency, place the entire electrical installation and/or any portion thereof, in operation to demonstrate satisfactory operation.
   5. The Contracting Agency may inspect and approve sample installation of systems and equipment prior to general installation of units.
   6. Test Witness: Arrange for the Contracting Agency to witness tests. The Contracting Agency may waive witnessing any specific test at its discretion.
   7. Tests: During final inspection, conduct operating tests for approval. Demonstrate installation to operate satisfactorily in accordance with requirements of Contract Documents. Should any portion of installation fail to meet requirements of Contract Documents, repair or replace items failing to meet requirements until items can be demonstrated to comply. Have instruments available for measuring light intensities, voltage, and current values and for the demonstration of continuity, grounds, or open circuit conditions. Furnish personnel to assist in taking measurements and making tests. In the event that systems are not complete and fully operational at the time of final inspection, all costs of any subsequent inspections shall be borne by the Contractor at no additional cost to the Owner.
   8. Certificate of Completion: Submit at time of request for final inspection, a complete letter in the following format:
      I,_____(Name), of_____(Firm), certify that the electrical work is complete in accordance with Contract Plans and Specifications, and authorized change orders (copies of which are attached hereto) and will be ready for final inspection as of_____(Date). I further certify that the following Specifications requirements have been fulfilled:
      a. Megger readings performed, ____ copies of logs attached.
      b. Operating manuals completed and instruction of operating personnel performed,

      _____ (Date) _____(Signed)
      Owner's Representative

c. Record document drawings up-to-date, accurate, and ready to deliver to Contracting Agency.
d. Emergency systems tested and fully operational.
e. Fire Alarm System tested and fully operational.
f. Security System tested and fully operational.
g. Telecommunications System test reports have been submitted to and approved by the Contracting Agency. The test reports shall certify that the Telecommunications System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.
h. Generation System and controls tested and fully operational.
i. Intercom/Clock System tested and fully operational.
j. Ground-fault system performance test complete, copies of logs attached.
k. Other tests required by Specifications have been performed.
l. Specified Owner training complete.
m. Systems are fully operational. Project is ready for final inspection.

SIGNED:_____DATE:_____
TITLE:_____

9. Operating Instructions: Prior to final acceptance, instruct an authorized representative of the Owner for eight hours on the proper operation and maintenance of electrical systems and equipment provided under this contract. This requirement is for several systems, and is in addition to special training specified in other sections. Make available a qualified technician for each component of the installation for this instruction. Give these operating instructions after the operation and maintenance manuals have been furnished to the Owner. Submit written certification, signed by the Contractor and an authorized representative of the Owner, that this has been completed.

1.7 WARRANTY

A. Warranty work shall be promptly coordinated and performed at the Contractor's sole expense. Workmanship, labor and materials (without limitation) in this Division shall be warranted for the longer of the following:
   1. As called for in the General Conditions of the Contract.
   2. For a minimum period of one year from the date of final acceptance.
   3. For the extended warranty period specified in a specific Section under this Division.

B. Where a specific product carries a longer warranty as a standard offering of its manufacturer, extended warranty coverage beyond these requirements shall be retained by the Owner. The Owner will have recourse back to the manufacturer only in these cases, when the warranty as specified in A above has expired.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT FURNISHED IN DIVISIONS 26 AND 27

A. Materials furnished and installed in permanent construction shall be new, full-weight, standard in every way, and in first class condition.

B. Materials shall conform to the standards of an organization acceptable to the Authority Having Jurisdiction and concerned with product evaluation that maintains periodic

inspection of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner. Only materials designed for the purpose employed shall be used.

C. Materials shall be identical with apparatus or equipment that has been in successful operation for at least two years. Materials of similar class or service shall be of one manufacturer.

D. Capacities, sizes, and dimensions given are minimums unless otherwise indicated. Systems, materials and equipment proposed for use on this project shall be subject to review for adequacy and compliance with Contract Documents.

2.2 MATERIALS AND EQUIPMENT FURNISHED IN OTHER DIVISIONS

A. Controls, including conduit, wiring, and control devices required for the operation of systems furnished in other Divisions shall be provided complete under the Division of the Specifications in which the equipment is specified, unless otherwise noted or specified.

B. Work on the project that falls under the jurisdiction of the electrical trade shall be performed by Licensed Electricians in conformance with the electrical specifications.

C. Provide complete power connections to equipment including but not limited to feeders, connections, disconnects and motor running overcurrent protection. Where starters are provided as part of packaged equipment, overcurrent heaters shall be provided under Divisions 26 and 27.

PART 3 - EXECUTION

3.1 COORDINATION WITH ROOM NUMBERING

A. Certain systems provided under this Division rely on identification systems that are based on room names or numbers. Systems labeled in this fashion include, but are not limited to, panelboards, circuit directories, communication and data systems identifiers, fire alarm systems, etc.

B. The numbering scheme indicated in these Contract Documents is based on room numbers assigned during the design process. The Owner reserves the right to change the numbers prior to substantial completion, and the final names and numbers will not necessarily match those found in the Documents. Obtain from the Owner the final room numbers prior to commencing the numbering of Divisions 26 and 27 systems. Tag and label all system circuits and devices in accordance with the final numbering scheme at no additional cost.

3.2 INSTALLATION

A. Skilled craftsmen shall install materials and equipment. The norms for execution of the work shall be in conformity with NEC Chapter 3 and the National Electrical Contractors' Association "National Electrical Installation Standards", which herewith is made part of these specifications.

B. Repair surfaces and furnish all required material and labor to maintain fireproof, airtight and waterproof characteristics of the construction.

C. Installation of equipment shall be in accordance with manufacturers' instructions.

3.3 MULTIWIRE BRANCH CIRCUITS

A. Multiwire branch circuits shall not be used on this project. Each branch circuit shall be provided with its own dedicated neutral conductor.

3.4 MOUNTING HEIGHTS

A. Mounting height shall be to center of box above finished floor (AFF) as noted below unless otherwise shown or indicated. Other mounting heights are indicated on the Drawings by detail. Specific dimensions AFF are shown adjacent to the symbol. Where devices are shown on architectural elevations, the elevation height shall govern.

Lighting switches	48 inches
Convenience outlets and similar devices	18 inches (see note below)
Convenience outlets in mechanical, boiler rooms and workrooms	48 inches
Motor controllers	60 inches to top
Panelboards	76 inches to top
Telephone panels	72 inches to top
Bracket lights	84 inches
Exterior WP convenience outlets	24 inches AFG
Clock hanger outlets and clocks	90 inches
Clock/speaker units	90 inches
Speakers	90 inches
Telecommunications (Data/Telephone) outlets	18 inches (see note below)
Range outlets	6 inches (or as required for access through drawer)
Dryer outlets	36 inches
Welder outlets	48 inches
Doorbell push buttons	48 inches
Wall mounted audible and/or visual appliances such as bells, horns, strobes and similar signal devices	90 inches (or 6 inches below ceiling height for ceiling heights less than 96 inches)
Manual fire alarm box	48 inches (or 48 inches to operable part where operable part of device is above centerline of device)
Fire alarm control panel	72 inches to top

Fire alarm graphic annunciator	72 inches to top
Fire alarm text annunciator	60 inches to center
Security Keypad	60 inches to center
Security Card Reader	48 inches to center
Intercom handsets and call-in switches	60 inches
Intercom administrative phone outlets	18 inches (see note below)

B. NOTE: In locations where baseboard-heating enclosures are to be installed, outlet-mounting height shall be raised to 6 inches above top of enclosure unless otherwise noted on drawings.

3.5 CUTTING & PATCHING

A. Obtain written permission of the Contracting Agency before cutting or piercing structural members.

B. Wall and floor penetrations shall be in accordance with Section 26 0529 - Hangers and Supports.

C. Holes through existing concrete shall be core drilled. X-ray concrete before core drilling. Do not cut rebar without specific authorization from the Contracting Agency. Seal openings with UL Listed fire resistant resilient sealant.

3.6 VAPOR RETARDER/BARRIER PENETRATIONS

A. Provide solid blocking installed flat at all vapor retarder penetrations. Provide flat blocking at the interior face of the exterior stud wall. Blocking shall be a minimum of 4 inches larger than the penetration. Locate the penetration at the centerline of the flat blocking. Secure vapor retarder to blocking.

B. Seal the interior of raceways penetrating the vapor retarder inside the building. Between point of sealing inside of raceway (typically at junction box or condulet) and vapor retarder penetration, seal conduit joints (connectors and couplings) with vapor retarder tape, paint on sealer or approved means acceptable to Contracting Agency.

C. To reduce thermal transfer and ensure sealing of raceway, PVC or equivalent conduit shall be used where penetrations of building envelope are made above ground where installation of PVC is allowed by NEC.

D. Penetrations of the building vapor retarder/barrier caused by the electrical installation shall be minimized, and where they are required, the opening in the vapor retarder/barrier shall be cut smaller than the penetrating object, so that the penetration will be a stretch fit. The penetration shall then be securely sealed with vapor barrier tape or an adhesive or caulk compatible with the surfaces being sealed.

E. Boxes (electrical boxes, outlet boxes and telecommunication boxes, etc) penetrating walls with vapor retarder/barriers shall be sealed airtight using STI Series SSP Firestop Putty Pads. Mold putty pads around electrical junction boxes and conduits and behind vapor retarder/barrier to form an airtight seal in accordance with manufacturer's installation instructions.

3.7 FIRE RESISTIVE CONSTRUCTION

A. Provide "tenting" or other protection acceptable to the Authority Having Jurisdiction for devices or fixtures installed in fire resistive construction (i.e., ceilings, walls, etc.) to maintain the fire resistive rating of the complete assembly.

B. Where electrical raceways or other features penetrate fire rated building surfaces, they shall maintain the integrity of the building surface being penetrated. This shall be accomplished with either of the following methods:
   1. Sealing the penetration with an approved fire rated caulk or putty.
      a. Fire rated caulk or putty: 3M Fire Barrier Caulk No. CP25, 3M Fire Barrier Moldable Putty, or as approved.
   2. A fire rated assembly enclosing the penetration.
      a. Fire rated assembly: STI EZ Path, or as approved.
   3. Firestopping shall be applied according to the manufacturer's recommendations, and in a manner that is listed by a nationally recognized independent testing agency (such as UL) as preserving the fire time rating of the construction.

3.8 PROTECTIVE FINISHES

A. Take care not to scratch or deface factory finish of electrical apparatus and devices. Repaint all marred or scratched surfaces.

B. Provide hot dip galvanized components for ferrous materials exposed to the weather.

3.9 SEPARATION OF SYSTEMS

A. Conductors and equipment of different voltage levels, frequency, current characteristics (AC & DC) or functions (normal vs. emergency, etc.) shall not share the same raceways or enclosures unless specifically shown on the Drawings or approved by the Contracting Agency, or inherently necessary for correct system function (i.e., at transfer switches, transformers, etc.)

3.10 TESTING

A. Prior to final test, switches, panelboards, devices and fixtures shall be in place.

B. Test electrical systems. They shall be free from short circuits and unintentional grounds.

C. Make changes necessary to balance the actual electrical loads on the complete system. Arrange for balanced conditions of circuits under connected load demands, as contemplated by the normal working conditions. Final load and balance test shall be demonstrated in the presence of the Contracting Agency.

D. Feeder cables and branch circuit cables larger than #4 AWG shall be megger tested prior to final termination. If conductor fails test, replace wiring or correct defect and retest. Perform a 1,000 volt megohm meter test between the following circuit cables in each raceway:
   1. A phase and B phase conductors
   2. A phase and C phase conductors
   3. B phase and C phase conductors
   4. A phase and Grounded (Neutral) conductors
   5. B phase and Grounded (Neutral) conductors
   6. C phase and Grounded (Neutral) conductors
   7. A phase and Equipment Grounding conductors
   8. B phase and Equipment Grounding conductors
   9. C phase and Equipment Grounding conductors
   10. Grounded (Neutral) and Equipment Grounding conductors

E. Feeder cables shall be megger tested prior to final termination. If conductor fails test, replace wiring or correct defect and retest. Perform a 1,000 volt megohm meter test on each circuit cable rated 600 volts between the conductor and ground. Submit logs of megger readings. The insulation resistance between conductors shall not be less than 100 Megohms.

F. Furnish one (1) copy of certified test results to the Contracting Agency prior to final inspection.

3.11 STORAGE AND HANDLING

A. Items shall be delivered and stored in original containers, which shall indicate manufacturer's name, the brand, and the identifying number. Items subject to moisture and/or thermal damage shall be stored in a dry, heated place. Items shall be covered and protected against dirt, water, chemical, ultraviolet (UV) and/or mechanical damage.

3.12 PROTECTION OF MATERIAL AND EQUIPMENT

A. The Contractor shall be responsible for materials and equipment to be installed under this Contract. The Contractor shall make good at his own cost any injury or damage which said materials or equipment may sustain from any source or cause whatsoever before final acceptance.

B. Cover and protect electrical equipment during construction from dust, dirt, debris, overspray, or other construction contaminates.

3.13 CLEANING AND REPAIR

A. Throughout the work, the Contractor shall keep the work area reasonably neat and orderly by frequent periodic cleanups.

B. Prior to substantial completion, clean equipment and systems used during construction.

C. Repair surfaces damaged or impacted by the work. Restore to original condition or better. Retexture surfaces to match surrounding surfaces. Repaint affected surfaces,

with extent of paint to include adjacent surfaces to next wall or other clean break to avoid mismatched finish.

D. As independent parts of the installation are completed, they may be tested and utilized during construction.

3.14 ACCESS DOORS

A. Provide access doors required for access to equipment provided under Divisions 26 and 27. Doors shall be rated for the surrounding construction. Use of access doors shall be minimized, and all locations and cosmetic features shall be submitted for approval in advance.

B. Doors shall be finished to match surrounding surfaces as approved by the Contracting Agency.

3.15 DEMOLITION

A. Examination Prior to Bid: Drawings involving existing conditions are based on building record drawings and/or limited field observation. Conduct a site inspection prior to submission of Bid to become thoroughly familiarized with the Scope of Work. Report discrepancies to Contracting Agency. Submission of bid certifies acceptance of existing conditions.

B. Examination Prior to Start of Demolition: Conduct a thorough site inspection before disturbing existing installation. Verify field measurements and circuiting arrangements. Verify that abandoned wiring and equipment serve only abandoned facilities. Beginning of demolition certifies acceptance of existing conditions.

C. Preparation:
   1. Disconnect electrical systems in walls, floors, ceilings, etc., scheduled for removal.
   2. Coordinate utility service outages with utility companies and Contracting Agency.
   3. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
   4. Existing Electrical Service: Maintain existing systems in service until new systems are complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 24 hours before partially or completely disabling system. Contractor shall not be entitled to any additional compensation due to inability of Owner to grant an outage at the desired time. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
   5. Existing Fire Alarm System: Maintain existing system in service. Disable system only to make switchovers and connections. Notify Owner and applicable Fire Department Authorities at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area. Provide fire watch for entire affected area for entire duration of outage. System outage shall not be considered terminated until the system has been tested and accepted.

D. Demolition of Existing Electrical Work:

1. Remove, relocate, and extend existing installations to accommodate new construction.
2. Remove abandoned wiring to source of supply.
3. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut concealed conduit flush with walls and floors, and patch surfaces.
4. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets, which are not removed. In finished areas, blank covers shall be blank plates matching the device plates specified for new work, unless otherwise noted or specified.
5. Disconnect and remove abandoned panelboards and distribution equipment.
6. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
7. Disconnect and remove abandoned light fixtures. Remove brackets, stems, hangers, and other accessories.
8. Repair adjacent construction and finishes damaged during demolition and extension work.
9. Maintain access to existing electrical installations that remain active. Modify installation or provide access panels as appropriate.
10. Restore circuits and systems to remain that are affected in any way by demolition Work, such as loads downstream of demolished equipment, switched lighting circuits where selected fixtures are demolished, etc.
11. Salvage or disposal of removed items shall be as noted on the Drawings or as directed by the Contracting Agency. Items, which the Owner does not desire to retain, shall be disposed of at a legal disposal site.

E. Cleaning and Repair:
   1. Clean and repair existing materials and equipment that remain or are to be reused or are affected by this work.
   2. Panelboards: Clean exposed surfaces and interior of cabinet and retorque electrical connections. Provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
   3. Light Fixtures: Remove existing light fixtures for cleaning. Use mild detergent to clean exterior and interior surfaces; rinse with clean water and wipe dry.

END OF SECTION 26 0000

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SECTION 26 0519

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes specific requirements, products, and methods of execution relating to wire and cable, 600 volts or less, approved for use on this project.

B. Related Sections
   1. 26 0533 - Raceways and Boxes for Electrical Systems
   2. 26 0553 - Identification for Electrical Systems

1.2 REFERENCES

A. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

B. National Fire Protection Association:
   1. NFPA 70 - National Electrical Code.
   2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

1.3 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

1.4 QUALITY ASSURANCE

A. Conductors shall be sized according to American Wire Gauge (AWG). Stranding, insulation, rating and geometrical dimensions shall conform to UL and ICEA specifications.

PART 2 - PRODUCTS

2.1 INSULATION TYPES

A. Branch circuit conductors shall be 600 volt insulated, and unless otherwise noted on the Drawings, shall have the following insulation types:
   1. Heated indoor spaces - THHN/THWN or XHHW.
   2. Outdoors, wet locations (such as slab-on-grade), or other cold locations (such as unheated attics) - XHHW.

B. Feeder conductors shall be 600 volt insulated, and unless otherwise noted on the Drawings, shall have the following insulation types:
   1. Heated indoor spaces - THHN/THWN or XHHW-2.
   2. Outdoors, wet locations (such as slab-on-grade), or other cold locations (such as unheated attics) - XHHW-2.

C. Nylon-jacketed conductors such as Types THHN or THWN shall not be used in any location subject to ambient temperatures below 20° F.

D. Special applications: Conductors in fluorescent fixture wiring channels shall have 90° C insulation rating, Types THHN, XHHW, or equal. Conductors in high temperature locations shall have one of the special insulation types suitable for the use and as permitted by the NEC.

E. Conductors feeding Variable Frequency Drives (VFDs) and between VFDs and equipment supplied by the VFDs shall be Type XHHW-2.

2.2 FLEXIBLE CORD

A. Flexible cord shall be Type SO or ST, or for the larger sizes, Type G.

2.3 MISCELLANEOUS

A. Miscellaneous: Miscellaneous wire and cable for special purpose applications and not covered in the categories as indicated above or otherwise specified, shall be as shown on the plans and/or required by the intended use.

2.4 MINIMUM SIZE

A. Unless specified otherwise minimum wire sizes shall be as follows:
   1. #12 AWG for branch circuit wiring.
   2. #20 AWG for low voltage switching circuits if part of an approved cable assembly, #18 AWG otherwise.
   3. #14 AWG for control circuit wiring.
   4. #16 AWG for light fixture whips, refer to specification section 26 0533 - Raceway and Boxes for Electrical Systems, for maximum fixture whip lengths.

B. On 20A circuits, with one-way conductor lengths measured from panel to farthest receptacle, or center of lighting string (as applicable):
   1. #10 AWG for 120V circuits of 75 feet to 120 feet.
   2. #8 AWG for 120V circuits of 120 feet to 200 feet.
   3. #10 AWG for 277V circuits of 130 feet to 215 feet.
   4. #8 AWG for 277V circuits of 215 feet to 330 feet.

C. Similar oversizing shall apply to circuits of other ratings and/or greater lengths, as necessary to comply with the voltage drop limitations in Part 3 of this Section.

D. Cable or conductors for fire alarm systems and other special systems shall be as described in other sections of the specifications, noted on the drawing, or recommended by the equipment manufacturer, whichever is greater.

2.5 CONDUCTORS

A. Conductors used on this project shall be copper, solid or stranded for wiring #10 and smaller, stranded for #8 and larger.

B. Stranded control, communication, and alarm conductors shall have compression terminations where terminated on screw terminals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unless otherwise noted or specified, all conductors shall be run in raceways as specified in Section 26 0533 – Raceways and Boxes for Electrical Systems. Raceways shall be installed as a complete system, free from obstructions, and clean before conductors are installed.

B. Provide conductors from outlet to outlet and splice branch circuit conductors only at outlet or junction boxes. Install all conductors in a single raceway at one time and leave sufficient cable at all fittings or boxes. Keep conductors within the manufacturer's allowable tension. Do not violate minimum bending radii. Lubricants for wire pulling, if used, shall conform to UL requirements for the insulation and raceway material.

C. Do not install Type XHHW conductors in temperatures below -10° F, or the other types in temperatures below +20° F.

D. Conductors that extend below grade shall be suitable for wet locations (type XHHW or XHHW-2). The use of THHN below grade is not acceptable.

3.2 CONDUCTOR SUPPORT

A. Provide conductor supports as recommended by the NEC or cable manufacturer in vertical conduits.

3.3 SPLICING

A. No splicing or joints are permitted in branch circuits except at outlet or accessible junction boxes. Prior to splicing, conductors shall be stripped to the exposed length recommended by the splicing device manufacturer.

B. Utilize compression type solderless connectors when making splices or taps in conductors No. 8 AWG or larger. Provide heat or cold shrink type insulating tubing on splices and tape outer surface continuously with Scotch #88 plastic tape to secure insulation strength equal to that of the conductors joined.

C. Utilize pre-insulated connectors, hard-shell type only, Ideal Industries, Inc., "Wing-Nut" or “Twister Pro” or "In-Sure Push-in Connectors" for splices and taps in conductors No. 10 AWG and smaller in dry locations.

D. Utilize Ideal “Twister DB Plus”, water repellent, sealant filled, UL 486D Listed connector splices and taps in conductors No. 10 AWG and smaller in damp or wet locations.

E. Utilize “Buchanan pre-insulated crimp connectors” on stranded conductors for fire alarm control and alarm circuits.

F. Feeder conductors shall be installed with no splices unless otherwise noted on the Drawings. Splices in feeder conductors, where specifically allowed, shall be compression type butt splices.

3.4 CONDUCTOR TERMINATION

A. Provide power and control conductors that terminate on equipment or terminal strips with solderless lugs or T & B "Sta-Kon" terminals.

B. Prior to termination, conductors shall be stripped to the exposed length recommended by the termination device manufacturer.

3.5 CONDUCTOR PHASE COLOR CODING

A. Service, feeder and branch circuit conductors throughout the project secondary electrical system shall be color coded as follows:

208/120 Volts	Phase	480/277 Volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray (see following)
Green	Ground	Green

B. Where color coded conductors are not commercially available, colored non-aging, plastic tape may be utilized where permitted by NEC.

C. Where neutrals of different systems exist on the project, neutral conductor identification method shall satisfy the Authority Having Jurisdiction, as to compliance with NEC Article 200. Branch circuit neutral conductors shall have a color stripe matching the corresponding phase conductor where neutral is not shared.

D. Phases in panelboards and similar equipment shall be connected Phase A, B, C from left to right, top to bottom, or front to back.

3.6 DERATING OF CONDUCTORS

A. Derating of conductors shall be per National Electrical Code.

3.7 VOLTAGE DROP

A. The maximum total voltage drop shall not exceed three (3) percent in branch circuits or feeders, for a total of five (5) percent to the farthest outlet based on steady state design load conditions. Wire sizes shown on the Drawings are for minimum ampacity. Wire and conduit sizes shall be increased to limit voltage drop based upon actual lengths required in the field. Base voltage-drop calculations on NEC Chapter 9, Table 9.

B. Secondary transformer voltage taps may be used to offset voltage drop as long as no load voltage does not exceed 125 volts phase to neutral/ground at transformer secondary.

3.8 TESTING

A. Feeder and branch circuit cables larger than #4 AWG shall be megger tested prior to final termination in accordance with Section 26 0000 – Electrical General Requirements.

END OF SECTION 26 0519

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SECTION 26 0526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general requirements, products and methods of execution relating to the furnishing and installation of a complete grounding system as required for this project.

1.2 REFERENCES

A. The publications listed below form a part of this specification. The publications are referred to in the text by basic designation only, latest edition.

NUMBER	TITLE
ANSI/IEEE C2	National Electrical Safety Code
ANSI/NFPA 70	National Electrical Code
ANSI/TIA/-606-C	Administration Standard for Commercial Telecommunications Infrastructure
ANSI/TIA-607-C	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
IEEE C62.41	Recommended Practice on Surge Voltages in Low-Voltage Surge Protective Devices
IEEE C62.42	Guide for the Application of Gas Tube Arrester Low-Voltage Surge Protective Devices
IEEE Draft P1250 (D4)	Guide on Service to Equipment Sensitive to Momentary Voltage Disturbances
IEEE Std 1100	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
IEEE Std 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE STD 81	Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth
NFPA 70	National Electric Code (NEC) - Codebook and Handbook
REA PE-33	(1985) Shield Bonding Connectors
UL 1449 Edition 3	Surge Protective Devices (SPDs)
UL 467 Edition 6	Grounding and Bonding Equipment
UL 497 Edition 5	Protectors for Paired Conductors for Communication Circuits
UL 497A Edition 1	Secondary Protectors for Communication Circuits
UL 497B Edition 1	Protectors for Data Communication and Fire Alarm Circuits

1.3 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1. Include copies of catalog cuts, data sheets and other descriptive information for all specified materials.

1.4 MINIMUM REQUIREMENTS

A. The minimum requirements for the system shall conform to Article 250 of the NEC.

1.5 SPECIAL REQUIREMENTS

A. Unless specified elsewhere, the ohmic values for grounds and grounding systems from system to earth shall be as follows:
   1. For grounding metal enclosures and frames for electrical and electronically operated equipment -- 5 ohms maximum.
   2. For grounding systems to which electrical utilization equipment and appliances are connected -- 5 ohms maximum.
   3. For grounding secondary distribution systems, neutrals, noncurrent carrying metal parts associated with distribution systems, and enclosures of electrical equipment not normally within reach of other than authorized and qualified electrical operating and maintenance personnel -- 10 ohms maximum.

PART 2 - PRODUCTS

2.1 CONNECTIONS

A. Joints in grounding conductors and mats below grade shall be made with exothermic welding process or hydraulically crimped fittings listed for direct burial. Terminations above grade shall be made with solderless lugs, securely bolted in place

B. Clamps, lugs, connectors, bonding bushings, and other such grounding and bonding items shall be:
   1. Labeled or listed for the purpose.
   2. Shall be made (both body and hardware) of hot dip galvanized steel, bronze, or other corrosion resistant alloy (except bushing throats shall be plastic).
   3. Shall be the products of O-Z/Gedney, T & B, Raco, or accepted equals.
   4. In outdoor, damp, or corrosive environments, metals for these items shall be copper (with or without tin-plating), bronze, or other corrosion resistant alloys only; O-Z/Gedney or accepted equal.

2.2 IDENTIFICATION AND LABELING

A. Grounding conductors shall be labeled in accordance with Specification Section 26 0553 and TIA/EIA-606-C.

PART 3 - EXECUTION

3.1 EQUIPMENT GROUND

A. The raceway system shall be bonded in conformity with NEC requirements to provide a continuous ground path. Where required by Code or Ordinance or where called for on the plans an additional grounding conductor shall be provided, sized in conformity with Table 250.122 of the NEC, unless larger size is noted.

B. Provide separate grounding conductor securely bonded and effectively grounded to the enclosures at both ends of all non-metallic raceways and all flexible conduit.

C. Provide an equipment grounding conductor sized in conformity with Table 250.122 of the NEC, unless larger size noted, for new feeder and branch circuit conduits. Where conductors are adjusted in size to compensate for voltage drop, equipment grounding conductors shall be adjusted proportionately according to circular mil area.

D. Refeeding existing feeder/branch circuits that do not have an existing equipment grounding conductor: Bond equipment grounding conductor of new feeder or branch circuit to junction box and new and existing conduits.

3.2 CONCEALED CONNECTIONS

A. Permanent grounding connections, where permitted by the NEC to be concealed, shall not be so concealed until inspected and accepted by the Contracting Agency. Failure to comply with this requirement shall make the Contractor liable for all expenses incurred in the process of re-exposing the connections for inspection, and subsequent repair and patching of the concealing construction, including the work of other trades. The Contractor shall schedule inspection of such connections at least one work week in advance of concealment, and shall not be entitled to any additional compensation or time extension for delays caused by inability of the Contracting Agency's representative to be available at the desired time.

3.3 CORDS AND NONMETALLIC CABLES

A. Unless specifically permitted otherwise, cords and nonmetallic cables shall be furnished with integral Code-sized grounding conductor. Securely bond metal components and effectively ground the entire electrical system.

3.4 SEPARATELY DERIVED SYSTEMS

A. Separately derived systems shall be grounded in accordance with NEC Article 250.30.
   1. System Bonding jumper:
      a. The system bonding jumper shall be sized in accordance with NEC Table 250.102(C)(1). Where the derived phase conductors are larger than 1100 kCMIL copper, the system bonding jumper shall have an area that is not less than 12-1/2 percent of the area of the largest ungrounded phase conductor.
      b. The system bonding jumper shall be used to connect the equipment grounding conductor (EGC) of the separately derived system to the grounded circuit conductor.

c. The system bonding jumper shall be located within the enclosure of the source of the separately derived system, unless specifically noted otherwise.

2. Grounding Electrode Conductor:
   a. The grounding electrode conductor shall be sized in accordance with NEC Table 250.66.
   b. The grounding electrode conductor shall be used to connect the system grounded conductor or EGC to a grounding electrode or to a point on the grounding electrode system.
   c. The grounding electrode conductor shall be connected and used to extend the connection to a grounding electrode at any of the following locations in accordance with NEC 250.68(C):
      1). Effectively grounded metal structural frame of a building.
      2). Effectively grounded interior metal water piping located not more than 5 feet from the point of entrance to the building.
      3). Effectively grounded rebar-type concrete-encased electrode, “Ufer Ground”, installed in accordance with NEC 250.52(A)(3) with an additional rebar section extended from its location within the concrete to an accessible location.
3. Grounding electrode:
   a. The grounding electrode shall be as near as practical to and preferably in the same area as the grounding electrode conductor connection to the system.
   b. The building or structure grounding electrode system shall be used as the grounding electrode for the separately derived system.
4. Provide termination lugs for the co-located grounded circuit conductor, grounding electrode conductor and system bonding jumper terminations, using Listed compression-type connectors suitable for all conductors landed at each location.

END OF SECTION 26 0526

SECTION 26 0529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:
   1. General hanger and support requirements for electrical equipment, conduit and cable trays not required to be vibration and/or seismically controlled.
   2. Penetrations, sleeves and seals.

B. Products Installed But Not Supplied Under this Section:
   1. Vibration Isolation and Seismic Control anchoring and support systems furnished under Section 20 0548 – Mechanical Vibration and Seismic Control.

C. Related Sections:
   1. 20 0548 - Mechanical Vibration and Seismic Control
   2. 26 0000 - Electrical General Requirements
   3. 26 0533 - Raceways and Boxes for Electrical Systems
   4. 26 2416 - Panelboards
   5. 26 2900 - Low Voltage Controllers
   6. 26 5000 - Lighting Fixtures
   7. 27 2010 -Telecom Distribution System
   8. Division 3 - Cast-In-Place-Concrete
   9. Division 9 - Painting

1.2 REFERENCES

A. NFPA 70: National Electrical Code (NEC) latest legally enacted edition.

1.3 DESCRIPTION

A. Provide general hanger and support requirements for electrical equipment, conduit and cable trays not required to be vibration and/or seismically controlled in accordance with the manufacture's written installation instructions and NFPA 70.

1.4 SUBMITTALS

A. See Section 26 0000 - General Electrical Requirements for general submittal requirements

B. Product Data:
   1. Provide manufacturers catalog data for each product specified. Indicate channel gauge and maximum load capacities of the selected products.
   2. Manufacturer's Installation Instructions: Include assembly instructions, recommended parts and special procedures as required.

C. Shop Drawings:

1. Provide a single shop drawing submittal which integrates the shop drawing requirements of this section
2. Provide shop drawings to include the following:
    a. Housekeeping pads (coordinated with approved electrical equipment footprints and anchor point locations).
    b. Pre-engineered and field fabricated support system details for each installation location. To include but not limited to:
        1). Raceway and lighting fixture support.
        2). Conduit and control panel support.
        3). Cable tray and switch box support.
        4). Cable tray support (single and multi-tier).
        5). Trapeze hangers.
        6). Electrical equipment support.
    c. Equipment locations and conduit and cable tray routing coordinated with mechanical equipment and systems. Indicate routing height above finished floor.
    d. Indicate hanger type/attachment method and hanger spacing intervals.

D. Project Record Information:
1. Indicate installed locations of hangers and supports on project as-built shop drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site:
1. Verify products are delivered in original factory packaging and are free from damage and corrosion.
2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

B. Storage and Protection:
1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
2. Handle items to avoid damage.
3. Replace damaged items with same item in new condition.

1.6 WARRANTY

A. Provide warranty in accordance with Section 26 0000 - General Electrical Requirements.

PART 2 - PRODUCTS

2.1 PRE-ENGINEERED SUPPORT SYSTEMS

A. Manufacturers:
1. Unistrut
2. Super-Strut
3. B-Line
4. K-Line
5. Erico.

B. Material:
   1. Cold worked steel.
   2. Type 304 stainless steel: Use for PVC, liquid-tight flex, or plastic-coated conduit installed on wood construction in outdoor, damp, corrosive or marine environments.

C. Finish:
   1. Heated indoor areas: Pre-galvanized zinc coating.
   2. Outdoor areas: Hot dipped galvanized finish. In addition, coat hot dipped galvanized finish channel field cuts with zinc rich paint provided by the support system manufacturer.
   3. Painted areas: Paintable galvanizing or phosphatized and primed.
   4. Surface metal raceways: U.L. Listed epoxy coating.

D. Channel:
   1. Standard Size: 1-5/8 inch x 1-5/8 inch. Gauge thickness as required for attached load.
   2. Standard Hole Pattern: Slotted. Provide solid channel in exposed public areas.

E. Nuts and Hardware:
   1. Channel nuts: Hardened steel (ASTM-A675 and ASTM A36).
   2. Bolts, screws and nuts: Hardened steel (ASTM-A307, ASTM A563 and SAE J429).
   3. Finish: Electroplated zinc.

F. Fittings: Plate steel (ASTM A635). Epoxy or electroplated zinc coating.

G. Electrical Accessories: Provide accessories from the support system manufacturer designed for the specific equipment to be supported to include but not limited to:
   1. Fluorescent fixture hangers.
   2. Outlet box adapters.
   3. Snap-in closures.
   4. Conduit connection plates.
   5. Junction box adapters.
   6. Strut joiners.
   7. "Caddy" fasteners are permitted for support of conduit to concealed metal studs and for conduit concealed above suspended acoustical ceilings.

2.2 SLEEVES, ACOUSTICAL SEALS AND FIRE-STOPPING

A. See Part 3 - PENETRATIONS.

B. Sleeves for pipes through fire rated and fire resistive floors and walls, and fire proofing: UL listed prefabricated fire rated sleeves and seals.

2.3 WALL/FLOOR PENETRATION WATER SEALS

A. Mechanical seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the conduit and the wall opening.

B. EPDM seals.

C. 316 Stainless steel bolts and nuts.

D. Hot-dipped galvanized or coated sleeve with full water stop flange with continuous weld on both sides.

E. Manufacturer: Metraflex, Thunderline, Crouse-Hinds, or pre-approved equal.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to installation, prepare detailed shop drawings of the planned installation of hanger and support products specified by this section. Coordinate the location, type and size of hangers and supports, housekeeping pads (thickness/perimeter overhang dimensions) and roof curbs with Architectural and Structural elements utilizing the shop drawing review process.

B. Submit shop drawings required by this for review and approval prior to construction.

C. Do not install hangers and supports without approved shop drawings.

3.2 GENERAL INSTALLATION

A. Install hangers and supports in accordance with manufacturer's instructions, applicable Code requirements (NFPA 70) and approved shop drawings.

B. See Section 26 0000 – Electrical General Requirements for electrical equipment wall mounting heights.

3.3 VIBRATION AND SEISMIC CONTROL PRODUCT INSTALLATION

A. Install vibration isolators, seismic control and wind restraint systems in strict compliance with the manufacturer's written instructions and certified and approved application engineering installation drawings and details.

3.4 INSERT AND ATTACHMENT INSTALLATION

A. Inserts
   1. Provide inserts or cast-in-place channels for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   4. Use expansion type anchor bolts with pre-cast concrete including concrete masonry units within loading limits of the pre-cast material and anchor bolt manufacturer's recommendations.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.
   6. Plastic screw inserts and caulked lead inserts are prohibited, except for mounting instructions and control diagrams.

B. Attach electrical equipment to structure as follows:
   1. Hollow masonry: Toggle bolts.
   2. Solid masonry and concrete: Preset inserts or expansion bolts.
   3. Structural steel: Beam clamps which engage both sides of structural member or have retaining clips or other approved means for positive engagement.
   4. Metal surfaces: Machine screws, bolts or welding.
   5. Wood construction: Wood or sheet metal screws. Bugle head drywall screws or deck screws are not allowed.
   6. Do not use powder actuated fasteners for anchorage in tension applications. Obtain written permission from the Owner prior to using any type of powder powered studs.
   7. Attachment to plaster or gypsum board (sheet rock) not approved. Equipment shall be attached to or supported from structure.

3.5 RACEWAY INSTALLATION

A. Support raceways using approved types of wall brackets, ceiling trapeze hangers or malleable iron straps utilizing attachment methods described above. "Perforated plumber's strap" is not permitted as a means of support.

B. Support raceways independent of ceiling systems, piping and ductwork. Exceptions: Lighting fixtures and outlet boxes (i.e. ceiling speaker boxes) specifically designed for attachment to suspended ceiling systems

C. Support EMT conduit (1-1/2 inch and smaller/dry locations) using hanger rods with spring steel fasteners.

D. Support cable trays and multi-conduit runs independently from other support systems utilizing double hanger rods at each support point.

3.6 LIGHTING INSTALLATION

A. General
   1. Attach safety hanger wires to lighting fixtures such that in event of a ceiling suspension system failure, no part of the fixture will drop more than 6 inches below normal ceiling height. Secure each end of each wire with a minimum of three tight wraps.

B. Fixtures (greater than 20 pounds/non-suspended ceiling applications)
   1. Support lighting fixtures from structural members capable of supporting the total weight of the fixture and independent from electrical wiring system. Attach to steel members using approved beam clamps and rods.

C. Fixtures (suspended ceiling system applications)
   1. Positively attach lighting fixtures to suspended ceiling grid for 100 percent of fixture weight acting in any direction using positive clamping devices that fully surround the supporting member (i.e. Caddy "IDS" or equal).
   2. Provide supplemental safety hanger wires as follows:
      a. Fixtures (weighing less than 56 pounds): Provide two 12 gauge wires or equivalent chains connected from the diagonal corners of the light fixture housing to the structure above. These wires may be slack.

b. Fixtures (weighting greater than 56 pounds): Provide full direct support from the structure above. Attach wires from within 3 inches of each corner of the fixture.
c. Pendant-hung lighting fixtures
   1). For each fixture, provide direct support from the structure above using a minimum of two 12 gauge wires, equivalent aircraft cable or an approved alternate support system without using the ceiling suspension system for direct support. Securely attach wire/cable to fixture, route through fixture stem and securely attached to structure.
   2). Provide loop and hook or swivel hanger assemblies fitted with a restraining device to secure stem in the support position during earthquake motion.
   3). Support fluorescent fixtures with flexible hanger device at the attachment point to the fixture channel to preclude breaking of the support. The motion of swivels or hinged joints shall not cause sharp bends in conductors or damage to insulation.

3.7 PENETRATIONS

A. Coordinate electrical penetrations with architectural, structural and mechanical construction details prior to installation. Set sleeves in position in concrete formwork. Provide reinforcement around sleeves as required.

B. Provide compatible materials, fasteners, adhesives, sealants, and other products required for proper installation.

C. Penetrations through roof, exterior walls and floors shall be weather and water tight (see floor penetration seals).

D. Firestopping: Provide UL rated firestopping assemblies for rated roof, wall and floor penetrations in accordance with Division 7.

E. Conduit Sleeves
   1. Provide sleeves for conduit passing through floors, walls, ceilings, or roofs.
      a. Fabricate sleeves in non-load bearing walls from 20 gauge galvanized sheet steel conforming to ASTM A 924/A 924M.
      b. Fabricate sleeves in load bearing walls from standard weight galvanized steel pipe conforming to ASTM A 53/A 53M.
      c. Provide 1/2 inch clearance between conduit and sleeve opening.
   2. Provide escutcheons for conduit passing through walls, floors and ceilings in finished areas, below counters and inside closets and casework subject to view when doors are open. Size escutcheons to cover sleeves. Secure escutcheons in position.

F. Acoustical Seals
   1. Monolithic sound walls (i.e. poured concrete or masonry): Provide wall sleeve with approximately one-inch annular space around conduit. Pack annular space with backer rod or acoustical filler as specified in Division 7. Allow a 1 inch recess at each end of sleeve. Caulk sleeve flush with flexible sealant or fire-stopping material as specified in Division 7.

2. Where acoustical wall is a two component type, such as a staggered or double stud partition, treat each component as a separate wall. Pack and seal each half of penetration sleeve as previously specified, except that only the exposed end of each sleeve portion shall be caulked with sealant or firestop. Provide adequate separation between each sleeve.

G. Wall Penetration Seals
   1. Provide pre-engineered wall penetration water seal systems for exterior wall penetrations.
   2. Select appropriate wall penetration sealing systems based on conduit material and nominal conduit size in accordance with the manufacturer's selection charts.
   3. Install conduit and sealing system prior to waterproofing the wall. Grout void between water seal and outside face of foundation wall to provide continuous bearing surface for waterproofing fabric.

H. Floor Penetration Seals
   1. Provide pre-engineered floor penetration water seal systems for conduit floor penetrations in rooms where a pipe leak/failure could result in water damage to adjacent spaces (i.e. mechanical rooms located above the ground floor or basement) and other areas as noted.
   2. Extend conduit floor penetration sleeves 2 inches above finished floor.

END OF SECTION 26 0529

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SECTION 26 0533

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes specific requirements, products, and methods of execution relating to conduit, conduit fittings, surface raceways, multi-outlet assemblies, wireways, outlet boxes, pull boxes and junction boxes approved for use on this project. Type, size and installation methods shall be as shown on Drawings, required by Code and/or specified in this Section.

B. Related Sections
1. 26 0519 - Low Voltage Electrical Power Conductors and Cables
2. 26 0526 - Grounding and Bonding for Electrical Systems
3. 26 0529 - Hangers and Supports for Electrical Systems

1.2 REFERENCES

A. American National Standards Institute/Underwriters Laboratory
1. ANSI C80.1 – Electrical Rigid Steel Conduit
2. ANSI C80.3 – Steel Electrical Metallic Tubing
3. ANSI C80.5 – Electrical Rigid Aluminum Conduit
4. ANSI C80.6 – Electrical Intermediate Metal Conduit
5. ANSI/UL 1 – Flexible Metal Conduit
6. ANSI/UL 6 – Electrical Rigid Metal Conduit – Steel
7. UL 6A – Standard for Electrical Rigid Metal Conduit – Aluminum and Stainless Steel
8. UL 360 – Standard for Liquid Tight Flexible Steel Conduit
9. UL 514A – Metallic Outlet Boxes
10. UL 514B – Conduit, Tubing and Cable Fittings
11. UL 651 – Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
12. ANSI/UL 797 – Electrical Metallic Tubing – Steel
13. ANSI/UL 1242 – Electrical Metal Intermediate Conduit – Steel

B. National Electrical Manufacturers Association
1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
2. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
3. NEMA OS 1 – Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports
4. NEMA RN 1 – Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
5. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
6. NEMA TC 3 – Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
7. NEMA WD 6 - Wiring Device Configurations.

C. NECA (National Electrical Contractors Association) Standard of Installation.

1.3 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

B. Product Data: Provide dimensions, knockout sizes and locations, materials, fabrication details, surface raceway finishes (custom factory pre-painting, color as selected by architect), and accessories.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.4 QUALITY ASSURANCE

A. Raceways and boxes shall be standard types and sizes as manufactured by a nationally recognized manufacturer of this type of materials and be in conformity with applicable standards and UL listings.

B. Surface raceways shall be of the latest approved design as manufactured by a nationally recognized manufacturer and shall be listed by the Underwriters' Laboratory and bear the UL label.

C. Pull and junction boxes 50 cubic inches and smaller shall conform to specifications for outlet boxes.

D. Pull and junction boxes larger than 50 cubic inches shall conform to U.L. Standard 50, Cabinets and Boxes.

E. Perform Work in accordance with NECA Standard of Installation.

F. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Conduit types specifically approved for use on this project shall be of the following types only:
   1. Galvanized rigid metal conduit - GRC or RMC.
   2. Intermediate metal conduit - IMC.
   3. Rigid copper-free aluminum conduit.
   4. Electrical metallic tubing - EMT.
   5. Polyvinyl chloride conduit - PVC: May be Schedule 40 or Schedule 80, except where Schedule 80 is specifically noted or specified.
   6. Flexible metal (steel) conduit - FMC or flex: In short lengths as specifically permitted.
   7. Liquid-tight flexible steel conduit - LFMC: In short lengths as specifically permitted.

8. Extreme temperature liquid-tight flexible steel conduit - AT: Shall have temperature rating of -67 ° F to +220 ° F, Liquatite “ATLA”, or as approved.

2.2 FIRE ALARM CONDUIT

A. EMT conduit utilized for fire alarm system wiring shall be factory pre-painted with a bright red topcoat, Allied Fire Alarm Red or as approved. Other conduit types utilized for fire alarm system wiring shall be identified with red paint or red tape wrapped a minimum of 4 times around the conduit every 10 feet and at each fire alarm system junction box.

2.3 CONDUIT FITTINGS

A. Fittings utilized with rigid steel, IMC, and aluminum shall be galvanized steel or iron or copper-free aluminum and shall be threaded. Conduit bushings shall be provided and shall be of the insulated types. Where grounding bushings are required, provide insulated grounding bushings with integral pressure type ground lugs, Thomas & Betts “Blackjack”, or as approved.

B. Couplings and connectors for EMT shall be made of steel or malleable iron. Die-cast products shall not be used. Connectors shall have insulated throats. Connectors and couplings shall be setscrew or compression type.

C. Fittings for flexible metal conduit shall be steel or malleable iron only. Throats shall be insulated.

D. Fittings for liquid-tight flexible conduit shall be steel or malleable iron, of a type incorporating a threaded grounding cone, nylon or plastic compression ring, and a tightening gland, providing a low resistance ground connection. Throats shall be insulated.

2.4 WIREWAY

A. Unless otherwise noted on the Drawings, surface wireway in exposed or concealed locations shall be sheet metal channel suitable for use as a wiring trough, with hinged or screw cover, sized in accordance with the NFPA 70. Wireway shall be Square D Class 5100, 5120, 5140, as appropriate for the environment, or as approved.

B. Wireway shall be of the NEMA Type (general purpose, oil-tight, dust-tight, rain-tight, etc.) appropriate for the environment where installed.

C. Wireway shall be furnished without factory pre-punched concentric or eccentric conduit knockouts. Knockouts shall be field punched as required for the conduits installed

D. Finish shall be ANSI-49 gray epoxy paint finish applied by cathodic electrodeposition over a corrosion resistant phosphate preparation.

2.5 CAST BOXES

A. Cast boxes with threaded hubs, external mounting brackets or holes, and gasketed covers shall be used in the following locations:
   1. Exterior locations.
   2. Wet or damp locations.

2.6 STEEL BOXES

A. Galvanized pressed steel boxes may be used wherever they are permitted by code, except in areas indicated in the preceding paragraph.

B. Flush mounted, pressed steel boxes shall be equipped with external mounting brackets for attachment to framing members with screws or nails.

C. Ceiling boxes and wall boxes for bracket lights shall be not less than 4 inch in diameter by 1 ¼ inch deep and shall have 3/8 inch malleable iron fixture studs if required.

D. Grounding Screw: All stamped steel boxes shall have a drilled and tapped hole in the back of the box for a grounding screw.

E. Accessories: Box covers, extension rings, bases, hanger bars, etc., for use in connection with the installation, shall be approved for use in the various applications.

2.7 TELECOMMUNICATION OUTLET BOXES

A. Boxes for telecommunication outlets shall be a minimum of 4 inches square by 2 1/8 inches deep.

B. Device rings for telecommunication outlets shall be single gang, minimum 5/8 inches deep, to provide a minimum internal finished depth of 2 3/4 inches.

2.8 INDOOR PULL AND JUNCTION BOXES

A. Indoor pull and junction boxes shall conform to Article 314 of the NEC and the following requirements:
   1. Sheet metal boxes are approved for use in all dry, interior, nonhazardous locations.
   2. Boxes installed in wet locations shall be NEMA 3R, unless otherwise noted.
   3. Furnish such boxes, whether shown or not, in order to conform to requirements for maximum pulling length and maximum number of bends allowed.
   4. Special boxes, as noted on the Drawings, shall be installed in areas of specific service and/or hazards.

B. Junction box extension rings will not be accepted on new boxes. Appropriate size boxes shall be used for each application.

2.9 TELECOMMUNICATION SYSTEM PULL BOXES

A. Telecommunication system Pull Boxes shall also conform to ANSI/EIA/TIA 569-A and the BICSI Telecommunications Distribution Methods (TDM) Manual.

B. Dimensions:

1. Pull boxes for straight through pulls shall have minimum interior dimensions in accordance with the following Table:

	Size of Box			
Maximum Trade Size Conduit	Width (inches)	Length (inches)	Depth (inches)	For Each Additional Conduit Increase Width
1 Inch	4	16	3	2 inches
1 1/4 Inch	6	20	3	3 inches
1 1/2 Inch	8	27	4	4 inches
2 Inch	8	36	4	5 inches
2 1/2 Inch	10	42	5	6 inches
3 Inch	12	48	5	6 inches
3 1/2 Inch	12	54	6	6 inches
4 Inch	15	60	8	8 inches

2.10 TELECOMMUNICATION SYSTEM SPLICE BOXES

A. Unless otherwise specified or noted on the Drawings, splice boxes shall not be used in interior horizontal pathway conduits or interior backbone pathway conduits.

B. Where required in a building service entrance or campus backbone pathway system, splice boxes shall be provided in accordance with the requirements of ANSI/EIA/TIA-569-A - Commercial Building Standard for Telecommunications Pathways and Spaces and the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual.

2.11 UNDERGROUND PULL AND JUNCTION BOXES

A. Boxes set in ground shall be either precast concrete or cast iron. Covers shall be galvanized steel or cast iron, and shall be bonded to the grounding system with a stranded grounding conductor secured with a grounding lug. Provide sufficient slack to allow removal of the cover and normal working access.

B. Underground concrete pull boxes installed in traffic areas shall be constructed to withstand AASHTO HS-20 wheel loading.

2.12 OUTDOOR ABOVE-GROUND PULL AND JUNCTION BOXES

A. Boxes exposed to rain or installed in wet locations shall be NEMA 3R unless otherwise noted.

B. Outdoor pull and junction boxes and conduit bodies for use with galvanized conduits shall be made of galvanized ferrous metal or cast aluminum, with integral threaded hubs or Myers-type weathertight hubs of matching composition and finish.

C. Furnish such boxes, whether shown or not, in order to conform to requirements for maximum pulling length and maximum number of bends allowed.

PART 3 - EXECUTION

3.1 CONDUIT USES PERMITTED

A. Conduits shall be of the sizes shown on the Drawings or as required by the NEC, whichever is larger. Base sizes on using type XHHW for wire sizes #6 and smaller and type THHN/THWN wire for wire sizes #4 and larger. Unless otherwise noted, conduits installed in the following locations shall be of the types specifically identified only:
   1. Outdoors aboveground or damp locations - RMC, IMC or extreme temperature liquid-tight flexible steel conduit (where required).
   2. Dry indoor locations, concealed or exposed - RMC, rigid aluminum, EMT (where not susceptible to physical damage), flexible conduit where necessary, or IMC.
   3. Indoor locations, exposed, where susceptible to physical damage - RMC or IMC.

3.2 RACEWAY INSTALLATION METHODS - GENERAL

A. Concealed raceways: In occupied areas, conduit and raceways shall be concealed unless specifically noted otherwise. In service spaces (mechanical equipment rooms, electrical rooms, storage closets, etc.), approved raceways may be surface-mounted for connection to equipment in exposed surface mounted locations and in exterior locations as noted on the Drawings.

B. Concealed raceways shall be routed as directly as possible with a minimum of bends. Concealed raceways above lay-in ceilings shall be installed a minimum of 12 inches above the ceiling grid.

C. Exposed Raceways: Where allowed by this Specification or specifically noted on the Drawings, raceways may be mounted on the surface of walls, ceilings and other surfaces. Exposed raceways shall comply with the following:
   1. Exposed raceways shall be run parallel or perpendicular to building lines and bent symmetrically or made up with standard elbows or fittings.
   2. Surface-mounted conduit, junction boxes, pull boxes, outlet boxes, etc. installed in finished areas shall be painted to match the surrounding surfaces.
   3. Connectors and fittings for raceways and conduits installed on the surface in exterior locations shall be suitable for and Listed for use in a wet location.
   4. Conduits installed in exterior locations shall be painted to match the exterior finish of the building surface to which they are attached. This shall include conduits attached via racks and stand-off brackets, or attached directly to the surface.

D. There shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points. Pull boxes added to conduit runs as a result of this requirement shall be in accordance with this Section.

E. Conduit and tubing shall be cut square and reamed smooth at the ends and all joints made tight. Conduit threads shall be lubricated with an approved thread lubricant.

F. Raceway for power wiring shall not be installed in the floor slab beneath telecommunication rooms.

G. Each conduit shall enter and be securely connected to a cabinet, junction box, pull box or outlet box by means of a locknut on the outside and a locknut/bushing on the inside,

or by means of a liquid-tight, threaded, self-locking, cold-weld type wedge adapter. Connections shall be made wrench tight. Locknuts shall be the bonding type with sharp edges and shall be installed in a manner that will assure a locking installation. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into threaded connections. Conduit runs shall be protected from the entrance of foreign material prior to the installation of conductors.

H. Conduit or tubing deformed or crushed in any way shall not be installed. Conduit shall be bent only with approved bender (hydraulic or hickey). Bending machines shall be used to make field bends in conduit of 1-1/4 inch size and larger. Torches shall not be used in making conduit bends.

I. Raceways shall be spaced at least 6 inches from parallel runs of heating system pipes, flues, other high temperature piping systems, and other heat sources. This basic spacing shall be increased if necessary to ensure that raceways experience no significant temperature rise from external sources. Raceways shall not be embedded in any spray applied insulation, fireproofing, or other materials that would restrict heat dissipation.

J. Pull wires shall be provided in spare and unused conduits. (Nylon "jet-line" or as approved.)

K. Conduits stubbed up out of floor and terminating inside of an enclosure shall have insulating grounding bushings installed.

L. Raceways penetrating vapor barriers or traversing from warm to cold areas shall be sealed on the inside with a non-hardening duct sealing compound to prevent the accumulation of moisture, and shall be taped airtight to the vapor barrier on the outside. Refer to Section 26 0000 for additional requirements and limitations regarding penetration of vapor barriers.

M. Raceways (particularly PVC) shall be provided with expansion joints where necessary to allow for thermal expansion and contraction. Set initial opening of expansion joints per manufacturer's instructions, to suit the ambient temperature at the time of installation.

N. Provide flexible conduit connection at seismic joints to allow for displacement of conduit in all three axes. Provide appropriate lengths of flexible conduits at seismic joints and appropriate amounts of slack in conduit to allow movement of conduit/cabling in accordance with the design of the seismic joint. Slack shall be maintained in conduit after cabling is installed. Minimum lengths of flexible conduit and minimum amount of slack for various size conduits shall be as follows:
   1. 2 inch and greater: 4 foot length, 4-6 inches slack.
   2. 1-1/2 inch and smaller: 2 foot length, 3 inches slack.

O. Flexible metal conduit with supplemental ground jumper shall be used for connection to vibrating equipment, or where installation conditions warrant its use with express permission. Flexible conduit shall not penetrate walls. Liquid-tight flexible conduit with supplemental ground jumper shall be used for motor and transformer connections (except utilize flexible metal conduit in plenum spaces). The ground jumper in flexible conduits shall be routed within the conduit.

P. Length of flexible conduit shall not exceed 36 inches, except for lighting fixture whips and where specifically noted. Fixture whips shall not exceed 72 inches. Flexible conduit shall not penetrate walls or vapor barrier retarder/barrier.

Q. Electrical raceways may penetrate roofing membranes only where absolutely necessary. Submit intended locations to Contracting Agency for approval prior to installation. Such penetrations shall be flashed and sealed as required for mechanical piping penetrations of roof. Where practical, conduits stubbed up to roof mounted equipment shall be routed within the equipment curb supporting the equipment.

3.3 RACEWAY INSTALLATION METHODS – TELECOMMUNICATIONS SYSTEMS

A. Installation methods for telecommunication system conduits shall comply with Installation Methods – General, above, unless superseded by more stringent requirements of this section.

B. Telecommunications conduits shall comply with the requirements of TIA/EIA-569-A and the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual. Note that some of these requirements are more stringent than the requirements of the National Electrical Code.

C. There shall be no more than two 90-degree bends between pull points in telecommunications conduit. Pull boxes added to conduit runs as a result of this requirement shall be in accordance with this Section. If it is not practical to install a pull box in the run due to field conditions, the conduit size shall be increased to the next trade size for each additional 90-degree bend. Offsets shall be considered as equivalent to a 90-degree bend.

D. Inside radius of conduit bends shall be at least 6 times the internal diameter of the conduit for sizes up to 2 inch trade size; 10 times the internal diameter of the conduit for sizes larger than 2 inch trade size. Where bending machine shoes are not available with the required bending radius for a one-shot field bend, factory bent, large radius 90-degree elbows shall be provided.

E. Conduits stubbed to cable trays shall be terminated within a maximum horizontal distance of 4 inches from the tray and in a vertical zone between 1 to 6 inches above tray. Conduits shall be supported from structure within a maximum horizontal distance of 12 inches from the tray. Conduits shall be provided with a grounding bushing and shall be bonded to the cable tray with a minimum 12 AWG copper conductor.

F. Use of flexible conduit for telecommunications shall be kept to a minimum and shall be at the discretion of the Contracting Agency. Obtain prior written approval for the use of flexible conduit. Where required due to physical considerations, flexible metal conduit may be allowed in lengths not exceeding 4 feet. If used, flexible metal conduit shall be increased by one trade size for the application used (see Conduit Sizes).

G. Conduits entering the telecommunications room or equipment room through the floor shall be terminated 4 inches above finished floor. Conduits entering the telecommunications room or equipment room from above shall be terminated 4 inches below the finished ceiling, but in no case shall the conduits terminate more than 12 inches above the cable pathway support or distribution frame.

H. Conduit sleeves connecting vertically "stacked" telecommunications rooms shall be terminated 4 inches above finished floor. Conduits and cutout openings between floors shall be sealed with firestopping material that is reusable, to accommodate additions and deletions, moves and changes in the cabling system.

I. Layout of conduits shall give consideration to nearby sources of electromagnetic energy such as electrical power wiring, large electric motors and generators, induction heaters, arc welders, variable frequency drives, etc. Maintain the greatest separation practicable between telecommunication raceways and sources of electromagnetic interference (EMI). A minimum of 5 inches of separation shall be maintained between telecommunication raceways and fluorescent lighting ballasts.

J. Pull wires shall be provided in spare and unused conduits. (Nylon "jet-line" or as approved.)

K. Maintain minimum separation from ≤ 480V power wiring in accordance with the following table:

Condition	Minimum Separation Distance		
	< 2 kVA	2-5 kVA	> 5 kVA
Unshielded power lines or electrical equipment in proximity to open non-metal telecommunications pathways	5 inches	12 inches	24 inches
Unshielded power lines or electrical equipment in proximity to a grounded metal telecommunications conduit pathway	2.5 inches	6 inches	12 inches
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a grounded metal telecommunications conduit pathway	--	3 inches	6 inches

3.4 CONDUIT SIZES – GENERAL

A. Minimum sizes for rigid steel, IMC, FRE, rigid aluminum and PVC-40 conduits shall be ¾ inch.

B. Minimum size for EMT shall be ½ inch.

C. Minimum size for flexible conduits shall be ½ inch , except fixture whips may be 3/8 inch as allowed by the NEC.

3.5 CONDUIT SIZES – TELECOMMUNICATIONS SYSTEMS

A. Minimum size for conduit runs to outlets is 1 inch.

B. Unless indicated otherwise, individual conduit homeruns shall serve no more than one telecommunications outlet.

3.6 STRUCTURAL COORDINATION

A. Structural members shall not be cut, drilled, or notched for raceways or other electrical features unless specifically accepted by the Contracting Agency.

B. Underfloor raceways for slab-on-grade construction shall be embedded in the fill under the slab, not in the slab itself. Where raceways are required or permitted to be embedded in concrete, the thickness of concrete on all sides of each raceway shall not be less than 2 inches.

3.7 EXISTING CONDUIT

A. Accurately measure the physical length of all existing underground conduits by the use of True Tape or an approved equivalent prior to the purchase or installation of any cable, wire, or innerduct. Costs incurred as a result of not obtaining accurate lengths of underground conduits prior to the purchase or installation of cable, wire, or innerduct; such as the need to replace cable, wire or innerduct, or provide an additional manhole or pull point, shall be the responsibility of the Contractor.

3.8 SURFACE RACEWAY INSTALLATION

A. Install Products in accordance with manufacturer's instructions.

B. Use flat-head screws, clips, and straps to fasten raceway channel to surfaces. Mount plumb and level.

C. Provide outlets in locations shown or according to spacing specified on the Drawings. Where spacing is specified, the maximum distance from each end of the raceway to the first outlet shall not exceed one-half of the specified spacing distance. Mounting elevations shall be as noted on the Drawings or as shown on the Architectural Elevations. If a conflict exists, the elevation shown on the Architectural Elevations shall take precedence.

D. Provide field paint touch-up with factory furnished paint to match factory pre-painted finish, for all chips, scraps, scratches, fittings and unpainted sections of the surface raceways and multi-outlet assemblies, after installation of all devices and covers are complete.

E. Provide appropriate separate device finish plates for outlets and telecommunication jacks as specified in other Sections.

F. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

G. Close ends of wireway and unused conduit openings.

H. Ground and bond raceways, multi-outlet assemblies and wireways under provisions of Section 26 0526 – Grounding and Bonding for Electrical Systems.

3.9 OUTLET BOX INSTALLATION

A. Outlet boxes shall be securely fastened in position and supported independently of the conduit system.

B. Outlet boxes located in suspended ceiling system shall be fastened to ceiling “t-bar” system with bar-hanger rods manufactured for the purpose, or from hanger rods with solid supports from structure above. “T-bar” hanger rods shall be clipped to cross-members supported by the main ceiling support members. Outlet boxes supported from the suspended ceiling system shall be provided with one safety wire attached to the box or box support clip, or two safety wires attached to the bar hanger.

C. Boxes shall be installed true to the building lines and at equal heights in conformity with mounting heights specified in other sections of the specification.

D. Provide the best suitable box for each outlet requirement. Extension rings shall not be used on new construction except where needed to bring an outlet box out to 1/8 inch of the finished wall or ceiling line.

E. Boxes shall have only the holes necessary to accommodate the conduits at point of installation. All boxes shall have lugs or ears to secure covers.

F. Boxes shall be rigidly secured in position. Recessed boxes shall be so set that the front edge of the box shall be flush with the finished wall or ceiling line, or not more than 1/8 inch back of same. This requirement is more stringent than NEC requirements.

G. Boxes shall be accessible.

H. Provide boxes for each application that will not violate the fire rating of the wall, floor or ceiling assembly in which the box is installed.

I. Do not place order for floor boxes without ensuring that the Contracting Agency has positively approved submittals for the specific cover types/styles colors necessary for all applications and locations.

J. Recessed boxes shall not be placed back-to-back in adjacent rooms. They shall be offset at least 12 inches, or greater as required by codes and standards applicable to the specific construction.

K. Boxes (electrical boxes, outlet boxes and telecommunication boxes, etc) penetrating fire rated walls, walls with vapor retarder/barriers, wall types that extend to structure or wall types that contain batts shall be sealed airtight with approved Firestop Putty Pads to reduce sound transmission, reduce air transmission and increase fire resistance. Mold putty pads around electrical junction boxes and conduits to form an airtight seal in accordance with manufacturer’s installation instructions.

3.10 JUNCTION BOX AND PULL BOX INSTALLATION

A. Junction and pull boxes shall be installed so that covers are readily accessible and adequate working clearance is maintained after completion of the installation.

B. Select boxes properly sized per NEC for power and lighting applications.

3.11 TELECOMMUNICATIONS SYSTEM PULL BOXES

A. Where a pull box is required in a 1 inch conduit run, outlet boxes as specified in this Section may be used. Where a pull box is required in a conduit run 1 1/4 inch or larger, or where required for multiple raceways, the box shall be sized in accordance with the Table in this Section.

B. Pull boxes shall be located in straight-through sections of horizontal cabling pathways (conduits). Pull boxes shall not be used for angle pulls or to accomplish changes in direction of the pathway.

C. Multiple raceways connecting to telecommunications system pull boxes shall penetrate box walls such that they are distributed evenly along the Box wall.

3.12 TELECOMMUNICATIONS SYSTEM JUNCTION BOXES

A. Telecommunications system interior pathways shall not contain junction boxes.

END OF SECTION 26 0533

SECTION 26 0553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide identification of on equipment, raceways, boxes and conductors.

B. Section includes:
   1. Nameplates
   2. Labels
   3. Wire markers
   4. Conduit markers
   5. Miscellaneous Electrical Identification

C. Related Sections: Divisions 26 and 27 Sections.

1.2 SUBMITTALS

A. Division 1 and Section 26 0000 – Electrical General Requirements.

B. Product Data:
   1. Submit manufacturer's catalog literature for each product required.
   2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Electrical Distribution Equipment Labels and Nameplates
   1. Name equipment in accordance with Contract Documents.
   2. Nameplates shall be laminated plastic, 0.125 inch thick, with matte finish and square corners. Minimum lettering size as noted elsewhere in this section.
      a. Label and Nameplate Colors:
         1). Normal Equipment: White letters on a black background.
      b. Temporary markings not permitted on equipment. Repaint trims, housings, etc., where markings cannot be readily removed. Refinish defaced finishes.
   3. Include item designation and branch circuit designation (panel and circuit number) on disconnects, starters, equipment and device nameplates, e.g., "FAN No. 4, Circuit LA-30").

2.2 WIRE AND CABLE MARKERS

A. Wire and Cable Markers: Wrap on labels, cloth tape type wire markers or tubing type for all phase, neutral and ground conductors.

2.3 LABELS

A. Adhesive film label with clear protective overlay: Machine printed, in black, by thermal transfer process or equivalent. Minimum lettering size as noted elsewhere in this section. Overlay shall provide a weatherproof and UV resistant seal for label.

2.4 UNDERGROUND ELECTRICAL LINE PLASTIC LINE MARKER

A. Minimum 4 inch wide plastic tape with metallic core with suitable legend describing buried electrical lines.

2.5 POWER ONE-LINE DIAGRAM

A. Laminated, approved print of the "As-Built" power distribution system. Install in accordance with Part 3.

PART 3 - EXECUTION

3.1 NAMEPLATE INSTALLATION

A. Install nameplate parallel to equipment lines.

B. Mechanically fasten nameplates using threaded fasteners or pop rivets.

C. Mechanical fasteners shall have no sharp edges or points which can damage conductors or injure personnel.

D. Temporary markings are not permitted on equipment. Repaint trims, housings, etc., where markings cannot be readily removed. Refinish defaced finishes.

E. No labeling abbreviations are permitted without prior approval.

3.2 DISTRIBUTION AND BRANCH PANELBOARD NAMEPLATES

A. Nameplate shall contain the following information (minimum ½ inch height letters):
   1. Line 1: Panel Name as noted on drawings and schedules.
   2. Line 2: Voltage and Phase.
   3. Line 3: Shall indicate if panelboard is "NORMAL" (black background), or "STANDBY" (yellow background) or "EMERGENCY" (red background).
   4. Line 4: Source from which panel is fed, “FED FROM: PANEL NH-031”.

B. Install a 2 inch x 4 inch nameplate on each branch panelboard where a building contains distribution systems of different voltages (minimum 1/8 inch height letters):

THIS BUILDING CONTAINS TWO WIRING SYSTEMS:				
	Phase A	Phase B	Phase C	Neutral
480Y/277V	Brown	Orange	Yellow	Gray
208Y/120V	Black	Red	Blue	White

3.3 NAMEPLATE LOCATIONS

a. (s) indicating the type and location of on-site emergency power sources.

B. Provide 1/2 inch minimum height letters on following equipment:
1. Secondary feeder breakers in distribution equipment. Designation as required by load served.
2. Special equipment housed in cabinets, as designated on plans, on outside of door.
3. Equipment housed in equipment cabinets, as designated on plans, on inside of cabinet door.
4. Switchboards, motor control centers, transformers, as designated on plans, on outside of door or equipment.
5. Emergency system equipment, boxes and enclosures, as designated on plans, on outside of equipment, boxes and enclosures.
6. Control or low voltage system panels such as Fire Alarm, Security, Video Surveillance, etc., with the following information:
   a. Line 1: Unique panel name as shown on the shop drawings.
   b. Line 2: System description such as Fire Alarm, Security, etc.
   c. Line 3: Panelboard and circuit number from which the panel is fed if applicable.

C. Provide 1/4-inch minimum height letters on:
1. Switchboards, switchgear and panelboards: Provide signage in accordance with NEC 408 indicating maximum available fault current and date of fault current calculation.
2. Disconnects, starters, VFDs and contactors:
   a. Line 1: Load Served (Use nameplate designation for source).
   b. Line 2: Panelboard and circuit number from which the device is fed.
   c. Line 3: Voltage, Phase, fuse size or circuit breaker size.
3. Lighting control relays, dimmer controls and remote lighting control equipment.
4. Switches and receptacles where item controlled is not visible from the switch, or as noted on Drawings.
5. External Power Sources: Provide 1/4 inch white letters on red background on all starters or controllers that receive power from an external source that is not de-energized by operating the associated disconnecting means.
6. Designated electrical equipment.

3.4 RECEPTACLE AND LIGHT SWITCH DEVICE PLATES

A. Provide 3/16 inch minimum height letters on receptacle and light switch device plates:
1. Provide clear adhesive label (black letter on clear background) indicating branch circuit designation (panel and circuit number) on receptacle and light switch device plates, e.g., “NPA-30”). Labels shall be printed not hand written.

3.5 TELECOMMUNICATION LABELING REQUIREMENTS.

A. Provide machine printed labels for all telecommunication racks, cabinets, patch panels, cables, outlets, etc., in accordance with ANSI/TIA/EIA-606-B. Provide labeling nomenclature in accordance with information on the Drawings or Owner's labeling conventions. Submit labeling samples for all required applications.

B. Machine Printed Label Requirements:
   1. PC Compatible.
   2. Can save and modify files.
   3. Fully integrated with AutoCAD.
   4. Editable Fonts and Sizes.
   5. Rotate Text and Objects.
   6. Vary Line Spacing.
   7. Ability to import graphical images.
   8. Capable for customization of layout.
   9. Re-positional labels.

C. Basis of Design:
   1. Brady Electrical/Datacomm Worldwide (latest version of LabelMark).
   2. Cable Management Software International (latest version of docIT).
   3. Approved alternate.

D. Labeling and color coding identification for this project shall conform to TIA/EIA-606-B for a Class 1 Administrative System.

3.6 LABEL LOCATIONS

A. Provide 3/16 inch minimum height letters on the following equipment:
   1. Security System Device Labels:
      a. Provide label on each security field device, denoting device address. Affix label to device faceplate for ceiling-mounted devices or wall mounted devices above 8'-0" AFF. Affix label inside back box for exterior devices.
   2. Fire Alarm Device Labels:
      a. Provide label on exterior surface of each initiating device denoting the unique device address corresponding to the text annunciator description. For detectors, the label shall be affixed to the base and not to the detector itself. For pull stations, the label shall be affixed to the top of the device and not to the vandal proof cover.
      b. Provide label on each remote test station indicating description and location of device being tested.
      c. Provide label on telecom conductors at each end denoting FACP lines for use with the digital alarm communicator transmitter (DACT).

3.7 DISTRIBUTION/BRANCH CIRCUIT PANELBOARD CIRCUIT LABELING

A. Distribution Panels and Branch Circuit Panelboard Directories: Provide neatly typed schedule (odd numbered circuits on left side or top, even on right side or bottom) under plastic jacket or protective cover to protect the schedule from damage or dirt. Securely mount on inside face of panelboard door. Define briefly, but accurately, nature of connected load (i.e., Lighting Room 201, Receptacles Janitor Room 155, Etc.) as approved. Sequentially numbered schedules shall not be used.

B. Use final approved room numbers from finished construction (not necessarily as indicated on the drawings).

C. Provide numbering for terminals on terminal strips in the terminal enclosure that identifies the origin, function and destination of each conductor.

D. Install wire marker for each conductor inside panelboards (phase, neutral and ground conductors). Locate label within 6 inches of termination. Labels shall be visible with panel dead front installed.

E. Dedicated branch circuit(s) feeding fire alarm control unit(s) shall be identified as “FIRE ALARM CIRCUIT” in accordance with NFPA 72. The circuit disconnecting means shall be identified with red marking.

F. Provide updated circuit directory in existing panelboards that are modified. Install directory in panelboard in protective cover and submit electronically in the O&M Manual.

3.8 WIRE MARKER INSTALLATION

A. Install wire marker for each conductor (phase, neutral and ground conductors) at panelboards, pull boxes, outlet and junction boxes, and each load connection. Locate label within 6 inches of termination in panelboards. Labels shall be visible with panel dead front installed.

B. Wire markers are not required on conductors in a pull or junction box that contains only an individual branch circuit, however, source panel and circuit number shall be noted on pull or junction box cover as noted elsewhere in this section.

C. Fire Alarm Circuits: Provide cable markers showing Notification Appliance Circuit (NAC) or Signaling Line Circuit (SLC) loop identification number at fire alarm junction boxes and pullboxes.

D. Security System Cables: Install wire marker for each cable at cabinets, pull boxes, junction boxes, and each load connection. Wire ID number shall be as shown on security system shop drawings.

E. Power Circuits: Panelboard name and branch circuit or feeder number.

F. Control Circuits: Control wire number as indicated on schematic and/or shop drawings.

G. Color Code:

1. Color code phases, neutral, and ground per NEC requirements and Section26 0519 – Wire and Cable.
2. Color code all low voltage system wiring in accordance with applicable Sections.

3.9 MISCELLANEOUS ELECTRICAL IDENTIFICATION

A. Junction Boxes: Mark the circuit number(s) and panel source of wiring on all junction boxes with sheet steel covers. Mark with indelible black marker. On exposed junction boxes in finished areas mark on inside of cover.

B. Conduits
1. Mark all conduits entering or leaving panelboards with indelible black magic marker with the circuit numbers of the circuits contained inside.
2. Fire Alarm System: Paint fire alarm conduits with a 6 inch band 10 feet on center with red paint where installed in concealed accessible location (or provide red conduit in accordance with Section 26 0519 – Low Voltage Electrical Power Conductors and Cables and Section 26 0533 – Raceways and Boxes for Electrical Systems. Where raceway is installed in exposed locations it shall be painted to match the adjacent surface.
3. Empty Conduits: Provide tags with typed description of purpose, and location of opposite end, wired to each end of conduits.

C. Junction Boxes
1. Markings shall be made with indelible black marker.
2. On exposed junction boxes in finished areas markings shall be on inside of cover.
3. Mark the circuit numbers of wiring on all junction boxes with sheet steel covers.
4. Mark all Special System junction boxes with sheet steel covers with appropriate system designation, e.g., "Intercom", "Clock", "Telecom", “Video Surveillance”, etc. Fire Alarm System: Paint all fire alarm junction boxes inside and out with red paint where installed in concealed accessible location. Where installed in exposed locations paint boxes to match the adjacent surface.

D. Exterior underground power, control, signal and communications lines.
1. Install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches provide additional markers.
2. Install markers for both direct buried and conduit encased conductors.
3. Label each underground conductor with its circuit number or identification tag.

E. Provide a label at the fire alarm control panel that identifies the panelboard and circuit number that supplies the control panel. Provide a red label adjacent to the circuit breaker inside the panelboard that clearly identifies the circuit breaker that feeds the control panel in accordance with NFPA requirements.

3.10 CODE REQUIRED MARKINGS AND WARNINGS:

A. Provide all placards, markings and identification systems required by Code and/or the Contract Documents, such as (but not limited to):
1. Arc Flash.
2. Series Rated Systems.

3. Conductor insulation color identification.
4. Special conductor identification and legends.
5. Emergency systems markings.
6. Emergency source grounded circuit conductor connected to a grounding electrode at a location remote from the emergency source: Provide a sign at the grounding location identifying all emergency and normal sources connected at that location.
7. Warning messages shall include an appropriate plain language imperative command, such as "DANGER HIGH VOLTAGE - KEEP OUT".
8. Available Fault Current: Service equipment shall be legibly marked in the field with the maximum available fault current. The field marking(s) shall include the date the fault calculation was performed and shall be of sufficient durability to withstand the environment involved.

3.11 CLEARANCE STRIPING

A. For electrical equipment located in areas with uncarpeted floors, the clearances dictated by NEC Article 110 shall be indicated by two inches wide colored striping on the floor.

B. Striping shall be of a bright color (typically red or yellow) that contrasts with the floor color, and shall be applied by the most durable process that is commercially available for the particular floor finish. Examples are: epoxy paint on concrete floors, and colored tile segments in composition tile floors. Striping color and method shall be subject to approval by the Contracting Agency.

C. On the floor immediately inside the striping, stencil in two inch block letters the statement: "ELECTRICAL CLEARANCE – NO STORAGE." For floor types where painted stenciling is not feasible or sufficiently durable, this message shall instead be posted on the wall below the equipment as an engraved nameplate of the type specified in this Section, with 1/2-inch lettering. Note the specific clearance requirements on the engraved nameplate.

END OF SECTION 26 0553

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SECTION 26 0919

ENCLOSED CONTACTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Lighting contactors.

B. Related Sections:
   1. 26 5000 - Lighting Fixtures

1.2 REFERENCES

A. NFPA 70 - National Electrical Code.

1.3 QUALITY ASSURANCE

A. Contactors shall be of the latest approved design as manufactured by a nationally recognized manufacturer and be Underwriters' Laboratory listed and bear the UL label.

B. Contactors of each type provided shall include the features as indicated on the Drawings.

1.4 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 1.

B. Accurately record actual locations of each contactor and indicate circuits controlled.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 1.

B. Maintenance Data: Include instructions for replacing and maintaining coil and contacts.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN

A. The Basis of Design is equipment from Square D by Schneider Electric to set a standard for quality. Equipment from alternative systems will be considered providing that sufficient documentation is provided to satisfy the CONTRACTING AGENCY that the equipment meets the requirements of the Specifications, and matches the Basis of Design on all points which are pertinent to the Project.

2.2 CONTACTOR FEATURES - GENERAL

A. Enclosures:
   1. For other than Panelboard Lighting Contactors, enclosures shall be ANSI/NEMA ICS 6, NEMA Enclosure Type as indicated or as required to meet conditions of the installation.

B. Accessories:
   1. Provide the following accessories as indicated for each contactor:
      a. Pushbutton: ON/OFF. NEMA ICS 2, heavy duty type.
      b. Selector Switches: ON/OFF or HAND/OFF/AUTOMATIC. NEMA ICS 2, heavy duty type.
      c. Indicating Lights: NEMA ICS 2 type.
      d. Auxiliary Contacts: field convertible, quantity indicated.
      e. Other: as indicated.

C. Coil Voltages: As indicated for each contactor.

D. Poles: As indicated or required for the specific application.

E. Contact Rating: As indicated or as required to meet conditions of the installation.

F. Size: As indicated or required by the load.

G. Configuration: Provide types as indicated:
   1. Electrically held shall have continuously rated, encapsulated coils.
   2. Mechanically held shall be electrically operated with encapsulated coils. Standard coil clearing contacts shall be provided so that the contactor coils shall be energized only during the instance of operation.

2.3 MULTIPOLE LIGHTING CONTACTORS

A. Square D Company - 8903 Type L & LX.

B. Description: magnetic lighting contactor.

C. Contact Rating: As indicated or as required to meet conditions of the installation.

D. Contacts: Totally enclosed, double break silver cadmium oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring. Contacts shall have clearly visible N.O. and N.C. contact status indicators.

E. Wiring: Straight-through wiring with all terminals clearly marked.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 NAMEPLATES

A. Provide engraved nameplates for Contactors in accordance with Section 26 0553 – Identification for Electrical Systems.

END OF SECTION 26 0919

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SECTION 26 2416
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general provisions, products, and methods of execution relating to branch circuit panelboards approved for use on this project. Type, size, ratings, etc., shall be as shown on the plans and in accordance with UL Standards 50 and 67.

B. Related Sections:
   1. 26 0526 - Grounding and Bonding for Electrical Systems
   2. 26 0553 - Identification for Electrical Systems
   3. 26 2800 - Low Voltage Circuit Protective Devices

1.2 REFERENCES

A. The panelboards and circuit breakers referenced herein shall be designed and manufactured according to the latest revision of the following specifications.
   1. NEMA PB 1 - Panelboards
   2. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
   3. NEMA AB 1 - Molded Case Circuit Breakers
   4. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
   5. UL 50 - Enclosures for Electrical Equipment
   6. UL 67 - Panelboards
   7. UL 98 - Enclosed and Dead-front Switches
   8. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures
   9. NFPA 70 - National Electrical Code (NEC)
   10. ASTM - American Society of Testing Materials
   11. IBC – International Building Code – Seismic compliance requirements
   12. NFPA 5000 – NFPA Building Code – Seismic compliance requirements
   13. ASCE 7 – American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures – Seismic compliance requirements
   14. ICC ES AC156 – International Code Council Evaluation Services Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems – seismic testing protocol

1.3 SPECIAL REQUIREMENTS

A. Special features such as integral surge protective devices (SPDs), etc., shall be provided as required by this Section and as noted on the Drawings or on the panel schedules.
   1. Trims shall be furnished to be compatible with type of mounting.
   2. “Door-in-door” construction shall be furnished on all panelboards unless otherwise noted.

1.4 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

B. Submit for approval manufacturer's shop drawings to show weights, dimensions, mounting arrangements, interconnecting diagrams, schedules of overcurrent devices, voltage ratings, and specified accessories.

1.5 QUALITY ASSURANCE

A. Panelboards shall be of the latest approved design as manufactured by a nationally recognized manufacturer and shall be listed by the Underwriters' Laboratory and shall bear the UL label.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN

A. The Basis of Design is equipment from Eaton Company to set a standard for quality. Equipment from Square D, Siemens Energy & Automation, General Electric, or alternative systems will be considered providing that sufficient documentation is provided to satisfy the CONTRACTING AGENCY that the equipment meets the requirements of the Specifications, and matches the Basis of Design on all points which are pertinent to the Project.

2.2 CABINETS AND FRONTS

A. Panelboard assembly shall be enclosed in a steel cabinet. Fronts shall include doors and have flush, brushed stainless steel, cylinder tumbler type locks with catches and spring-loaded door pulls. All panelboard locks shall be keyed alike. Fronts shall have adjustable, indicating trim clamps that shall be completely concealed when the doors are closed. Doors shall be mounted by completely concealed steel hinges. Fronts shall not be removable with door in the locked position. A circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door. The directory card shall provide a space at least 1/4 inch high by 3 inch long or equivalent for each circuit. The directory shall be typed to identify the load fed by each circuit. Fronts shall be of code gauge, full finished steel with rust inhibiting primer and baked enamel finish. Cabinets shall be labeled in accordance with the Drawings and Section 26 0000 - Electrical General Requirements.

B. “Door-in-door” construction shall be furnished on panelboards unless otherwise noted.

2.3 SAFETY BARRIERS

A. The panelboard interior assembly shall be dead front with panelboard front removed.

2.4 BUS ASSEMBLY

A. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on the panelboard schedule. Bus structure shall allow 1, 2 and 3-pole breakers of various frame sizes to be mounted in any location and in any combination up to the capability of the panel.

2.5 SHORT CIRCUIT CURRENT RATING

A. Each panelboard, as a complete unit, shall have a short circuit current rating (SCCR) equal to or greater than that shown on the panelboard schedule, or as necessary to comply with the requirements stated on the power one-line diagram. The SCCR rating shall not, in any case, be less than 10,000 Amps at 240 volts, and 14,000 Amps at 480 volts.

2.6 PROTECTION DEVICES

A. Circuit breakers shall individually comply with Section 26 2800 – Low Voltage Circuit Protective Devices. The type to be furnished shall be as shown on the plans. If no withstand rating is specified, minimum requirements shall be as necessary to comply with the preceding requirements.

2.7 NEUTRAL TERMINAL BAR

A. Panelboards shall be equipped with an insulated neutral terminal bar.

2.8 EQUIPMENT GROUNDING TERMINAL BAR

A. Panelboards shall be equipped with an equipment grounding terminal bar to terminate equipment grounding conductors.

2.9 HANDLE LOCK-OFF EQUIPMENT

A. Circuit breakers serving as the required disconnecting means for appliances or other equipment shall be equipped with equipment to allow the breaker to be padlocked in the "off" position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify mounting arrangements for each location shown on the plans. Where cabinets are recessed, verify adequate thickness of wall and make arrangements for furring or trim as required. In general, conduits shall enter the top or bottom of panel.

B. Provide additional wire gutters or pull boxes to facilitate orderly entry of conduits into cabinets. Bundle and support wires and arrange them in an orderly manner in the designated wire gutters.

C. Panelboards shall not be used for pull boxes for wiring not terminating in the panelboard.

3.2 SPARE CONDUITS

A. Provide spare conduits from flush mounted panels into accessible ceiling or floor spaces as follows:

No. of Poles (Spares + Spaces)	Spare Conduits
1 - 3	One 3/4 inch
4 - 6	Two 3/4 inch
7 or more	Two 3/4 inch, One 1 inch

3.3 PANELBOARD LABELS

A. In addition to applicable NEC requirements for emergency systems, series rated applications, etc., label panelboards in accordance with Section 26 0553 – Identification for Electrical Systems.
   1. First line shall be panelboard name.
   2. Second line shall be voltage and phase.
   3. Third line shall indicate if panelboard is "NORMAL" (black background), or "STANDBY" (yellow background) or "EMERGENCY" (red background).
   4. Fourth line shall be source from which panel is fed, “FED FROM: PANEL NH031”.

B. Install a 2 inch x 4 inch nameplate on each branch panelboard where a building contains distribution systems of different voltages:

THIS BUILDING CONTAINS TWO WIRING SYSTEMS:				
	Phase A	Phase B	Phase C	Neutral
480Y/277V	Brown	Orange	Yellow	Gray
208Y/120V	Black	Red	Blue	White

3.4 FIELD QUALITY CONTROL

A. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.

B. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

3.5 SHORT CIRCUIT INFORMATION/PANEL SCHEDULES

A. Refer to the drawings for Short Circuit Information and Panel Schedules.

END OF SECTION 26 2416

SECTION 26 2726
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general provisions, products and methods of execution relating to line voltage wiring devices for use on this project.

B. Related Sections
   1. 26 0533 - Raceway and Boxes for Electrical Systems

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA WD 1 - General Requirements for Wiring Devices.
   2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

1.3 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

B. Do not place order for devices, plates, etc., without ensuring that the Contracting Agency has positively approved submittals for the specific colors necessary for all applications and locations. Note that the selection of one color for general use does not rule out the selection of other colors for special applications or for aesthetic reasons.

1.4 QUALITY ASSURANCE

A. Manufacturers mentioned and catalog numbers specified are for establishment of type, configuration and quality. Other manufacturers and types may be submitted for approval.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Catalog numbers shown are Hubbell unless noted otherwise. Equal devices manufactured by Arrow Hart (by Cooper Wiring Devices), Pass and Seymour, Leviton and Bryant are acceptable. Provide all similar devices of same manufacturer.

2.2 SWITCHES

A. Provide 20 AMP, 120V rated switches with UL listing for tungsten lamp loads or inductive loads without derating. Switches shall be as follows:

	20A Rated Switches
Single Pole	CAT. NO. HBL1221W
Three-way	CAT. NO. HBL1223W
Four-way	CAT. NO. HBL1224W
Key Operated	CAT. NO. HBL1221LW
Momentary Cont.	CAT. NO. HBL1557W
Double Pole	CAT. NO. 1222W
Pilot Switch	CAT. NO. HBL1221PLC

B. Other switch types shall be provided as called for on the Drawings or as required by the application.

2.3 RECEPTACLES

A. Insofar as commercially available, receptacles shall be of nylon construction. Provide grounding type receptacles as follows, or as required to match equipment furnished in this or other divisions.

Single Phase, 3-Wire Devices		
20A-125V USB Charger Tamper Resistant	CAT. NO. HBL USB20X2	NEMA #5-20R
20A-125V	CAT. NO. HBL5362W	NEMA #5-20R
20A-125V GFCI	CAT. NO. HBL GF-20W	NEMA #5-20R
20A-125 SPD	CAT. NO. HBL5362SA	NEMA #5-20R
20A-125V Tamper Resistant	CAT NO. HBL5362WTR	NEMA #5-20R
20A-250V Single	CAT. NO. HBL5461W	NEMA #6-20R
30A-250V Dryer	CAT. NO. RR430F	NEMA #14-30R
50A-250V Range	CAT. NO. RR450F	NEMA #14-50R

B. Outlets requiring ratings and configurations different from those listed above shall be provided as shown on the plans and/or required by the equipment served.

C. Provide suitable wireguard and mounting hardware for surface or corner mounted devices in Multipurpose Rooms (MPRs), Gymnasiums and where indicated on the Drawings.

D. Other products may be submitted if they provide equal or better performance to the products specified as the Basis of Design. The substitution request shall include a feature by feature comparison to the specified products or the request will not be reviewed. Substitutions are subject to approval. Samples may be required by the Electrical Engineer for evaluation of performance. Samples will not be returned.

2.4 DEVICE COLOR

A. Device color shall be white, unless otherwise noted.

2.5 DEVICE PLATES

A. Device plates shall be made of high impact nylon, unless otherwise noted. Device plate color shall be white, unless otherwise noted.

B. Indoor device plates for surface mounted boxes shall be stainless or galvanized steel, with design to match the box and device type being used.

C. Weatherproof outlet plates shall be of the safety outlet enclosure type that can be closed to remain weatherproof while in use. The outlet cover/enclosure shall be clearly marked “Suitable for Wet Locations While In Use” and “UL Listed”. A gasket shall be provided between the enclosure and the mounting surface, and between the hinged cover and the mounting plate/base to ensure a proper seal. Enclosure shall be oversized depth, single-gang, vertical-mount, with non-locking latch, GFCI opening, cord openings, and cover; TayMac; Specification Grade or approved equal.

D. Label receptacle and light switch plates in accordance with Section 26 0553 – Identification for Electrical Systems.

2.6 PHOTOCELLS

A. Outdoor Photocells
   1. Basis of design is Intermatic K4236C Stem and Swivel Mounting Photocell.
   2. Photocell shall have minimum of 2400 V open type spark gap arrestor to protect against voltage surges.
   3. Photocell shall be weatherproof or be provided with weatherproof case.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wiring devices indicated complete with cover plates. Cover plates shall fit snugly against finished surfaces and line up true with adjacent building lines, and be symmetrical in location and appearance.

B. Switches shall be installed so their handles move in a vertical plane.

C. Door swings shall be checked and, if necessary, switches shall be relocated to place them on the strike side of the door.

D. Unless otherwise noted on the drawings, receptacles shall be installed in the vertical position with the grounding pin down unless wording on the face of the device requires other mounting.

E. Receptacles identified as Ground-Fault Circuit Interrupter (GFCI) type shall be provided as individual GFCI receptacles

F. NEMA 5 configuration receptacles located in shops or commercial kitchens whether on single or multiple receptacle circuits shall be rated at least 20 amps.

END OF SECTION 26 2726

SECTION 26 2800

LOW VOLTAGE CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Thermal Magnetic Molded Case Circuit Breakers.
   2. Fusible switches and fuses.

B. Related Sections:
   1. 26 2416 - Panelboards

1.2 REFERENCES

A. The circuit breaker(s) referenced herein shall be designed and manufactured according to the latest revision of the following standards.
   1. ANSI/NFPA 70 - National Electrical Code (NEC).
   2. NEMA AB 1 - (National Electrical Manufacturers Association) Molded Case Circuit Breakers and Molded Case Switches.
   3. UL 489 - (Underwriters Laboratories Inc.) Molded Case Circuit Breakers and Circuit Breaker Enclosures.
   4. UL 943 - Standard for Ground Fault Circuit Interrupters.
   5. UL 1053 – Ground Fault Sensing and Relaying Equipment.
   6. CSA C22.2 No. 5 - (Canadian Standard Association) Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures.
   7. Federal Specification W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
   8. Federal Specification W-C-865 - Fusible Switches.
   9. IEC 60947 – Low Voltage Switchgear and Control Gear – Part 2: Circuit Breakers.
   10. IEC 61000-4 Series – Electromagnetic Compatibility.

1.3 SYSTEM DESCRIPTION

A. Provide overcurrent protective devices as specified herein and as shown on schedules and/or drawings.

1.4 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

B. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Submit product data for each type of overcurrent protective device, ground fault protector, accessory, and component indicated. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Provide outline drawings with dimensions, and ratings for voltage, amperage and maximum interruption. Include instructions for circuit breaker mounting, trip unit functions and adjustments, trouble shooting, accessories and wiring diagrams.

D. Coordination data to check protective devices: Manufacturer shall provide electronic and hard copy time/current characteristic trip curves (and Ip & I^2t let through curves for current limiting circuit breakers) for each type of circuit breaker.

E. Provide information required to verify compliance with the short circuit withstand and interrupting ratings, as shown on the Drawings or further stated in these Specifications.

1.5 QUALITY ASSURANCE

A. Devices shall be the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with applicable standards and UL listings.

B. Nationally Recognized Testing Laboratory (NRTL) Labeling: Electrical equipment and conductors installed in the State of Alaska must be "Approved," "Certified," "Identified," or "Listed" and "Labeled" to establish that the electrical equipment is safe, free of electrical shock and fire hazard, and suitable for the purpose for which it is intended to be used. The manufacturer shall have the specific authorization of one of the Occupational Safety and Health Administration (OSHA) approved Nationally Recognized Testing Laboratories (NRTLs) in accordance with the applicable national standards to label the equipment as suitable.

C. The overcurrent protection device manufacturing facility shall be Registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9000 Series Standards for quality.

PART 2 - PRODUCTS

2.1 PRODUCT

A. The Basis of Design is equipment from Square D by Schneider Electric to set a standard for quality. Equipment from Eaton, Seimens Energy & Automation, General Electric, or alternative systems will be considered providing that sufficient documentation is provided to the Contracting Agency that the equipment meets the requirements of the Specifications, and matches the Basis of Design on all points that are pertinent to the Project.

2.2 MOLDED CASE CIRCUIT BREAKERS

A. General Characteristics:
   1. Circuit breakers shall be constructed using glass reinforced insulating material. Current carrying components shall be completely isolated from the handle, and the accessory mounting area.
   2. Circuit breakers shall have an over center, trip free, toggle operating mechanism which shall provide quick make, quick break contact action. The circuit breaker shall have common tripping of all poles.

3. The circuit breaker handle shall reside in a tripped position between on and off to provide local trip indication. Circuit breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings.
4. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
5. Each circuit breaker shall be equipped with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit breaker tripping mechanism for maintenance and testing purposes (except Type QO/EDB/EGB/EJB).

B. Trip Unit:
   1. General:
      a. MCCBs with ratings up to 400 amperes shall be equipped with thermal magnetic trip units.
      b. Circuit breakers with permanent trip units shall be UL listed for reverse connection without restrictive line and load markings and shall be suitable for mounting in any position.
      c. The trip units shall not augment overall circuit breaker volume.
   2. Thermal Magnetic (400 Ampere Frame and Below) :
      a. Basis of Design: PowerPact Q, H and J Frame, FA, LA, and LH as manufactured by Square D by Schneider Electric.
         1). General:
            a) Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true RMS sensing and thermally responsive to protect circuit conductor(s) in a 104 F (40 C) ambient temperature. Circuit breaker frame sizes above 150 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker
         2). Type QO (for use in NQ Series Panelboards) and Type EDB/EGB/EJB (for use in NF Series Panelboards) as manufactured by Square D by Schneider Electric.
            a) Breakers shall have two forms of visible trip indication. The breaker handle shall reside in a position between ON and OFF. In addition, there shall be a red VISI-TRIP® indicator appearing in the clear window of the circuit breaker housing.

2.3 FUSIBLE SWITCHES

A. Main Fusible Devices
   1. Fused Power Circuit Devices
      a. Individually fixed mounted bolted pressure switches through 4000 A.
      b. Each device shall have power terminals to accommodate either cable or bolted bus connections.
      c. The over current protective devices shall be of the fusible bolted pressure contact type as shown on the associated drawings.
      d. Switches, with Class L fuse installed, shall be rated for use on systems capable of delivering not more than 200,000 rms symmetrical amperes at 600 VAC maximum. Switches shall have an interrupting rating of 12 times continuous ampere rating at 240, 480, and 600 VAC. Switches shall be 100% rated devices. Lugs shall be rated for use with 90° C wire insulation (sized according to the 75° C temperature rating in the NEC).

e. Switches shall have switch blades which are fully visible in the Open (off) position when the fuse access door is open. Bolted pressure contacts shall be made by providing an additional pressure or clamping action at both ends of the switch blade when the blades are fully closed. Switches having butt-type contacts are not acceptable.
f. Manual operated switches shall have quick-make, quick-break front operating mechanisms.
g. Provisions for locking the switch in the Open (off) position with at least three padlocks shall be provided. Switches shall have dual fuse door interlock designed to prevent the fuse access door from being opened when the switch is Closed (on) and prevents the switch being turned ON while the fuse access door is open. A means of bypassing the interlock by authorized personnel shall be provided to allow the switch to be inspected in the Closed position. An external mechanical flag shall be provided to identify whether the switch is either Open or Closed.
h. Switches shall be BOLT-LOC as manufactured by Square D.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings. Install circuit breakers in accordance with manufacturer's instructions, the National Electrical Code and applicable local codes.

B. Size devices as shown and specified, or as required by the load being served.

3.2 ARC FLASH LABELING

A. Provide arc flash labels for equipment that provides all of the following:
   1. Nominal system voltage
   2. Arc flash boundary
   3. At least one of the following:
      a. Available incident energy level or arc flash PPE Category in NFPA 70E, Standard for Electrical Safety
      b. Minimum arc rating of clothing
      c. Site specific level of PPE

3.3 FIELD QUALITY CONTROL

A. Document each installation and operational step in accordance with approved shop drawings and manufacturer's requirements.

END OF SECTION 26 2800

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general requirements, products, and methods of execution relating to fusible and non-fusible disconnecting devices approved for use on this project.

B. Related Sections:
   1. 26 0519 - Low Voltage Electrical Power Conductors and Cables
   2. 26 0526 - Grounding and Bonding for Electrical Systems
   3. 26 0529 - Hangars and Supports for Electrical Systems
   4. 26 0553 - Identification for Electrical Systems

1.2 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

1.3 QUALITY ASSURANCE

A. Devices shall be of the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with U.L. listings and the governing NEMA standards.

B. Disconnects shall be of the same manufacturer as switchboards and panelboards.

PART 2 - PRODUCTS

2.1 SAFETY SWITCHES

A. Safety switches, fusible and non-fusible, shall conform to NEMA Standard KS1 for type HD (Heavy Duty) unless otherwise noted.
   1. Switch Interior: Switches shall have switch blades that are fully visible in the OFF position when the door is open. Switches shall be of dead front construction with permanently attached arc suppressers. Lugs shall be UL listed for copper and/or aluminum cables and be front removable.
   2. Switch Mechanism: Switches shall have a quick-make and quick-break operating handle and mechanism that shall be an integral part of the box, not the cover. Switches shall have a defeatable dual cover interlock to prevent unauthorized opening of the switch door in the ON position or closing of the switch mechanism with the door open. The switch shall be capable of being locked in the OFF position with three (3) padlocks.
   3. Enclosures: Switch enclosure shall be suitable for the environment in which the switch is mounted. NEMA 1 enclosure shall be code gauge, UL-98, sheet steel, treated with a rust inhibiting phosphate and finished in gray, baked enamel.

NEMA 3R enclosure--same requirements as NEMA 1 except galvanized prior to painting.

4. Rating: Ampere, volt and horsepower ratings, as well as number of poles and presence of neutral bar shall be shown on the nameplate.

2.2 CIRCUIT BREAKERS

A. Circuit breakers used as disconnects shall meet requirements specified in Section 26 2800 – Low Voltage Circuit Protective Devices. Enclosures for same shall meet the requirements as specified above.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate details pertaining to size of motor and/or equipment, location and requirements to enclosure, ratings, etc., so as to provide the most suitable unit for the intended purpose.

B. Provide nameplates for disconnects. Coordinate names with mechanical equipment lists.

C. Where the rating of a fused disconnect exceeds the ampacity of the conductors being protected, a permanent label noting maximum fuse size shall be installed in a conspicuous location within the switch.

D. Where recommended or required by the equipment manufacturer, or required by underwriters' laboratories, disconnects shall be the fusible type, fused in accordance with the equipment nameplate information.

E. Provide code required disconnects. For equipment under the jurisdiction of the IMC, provide a disconnect within sight of the equipment.

END OF SECTION 26 2816

SECTION 26 2900
LOW VOLTAGE CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general requirements, products, and methods of execution relating to manual and magnetic motor starters provided in this and other Divisions. Overloads shall be furnished and installed in Division 26.

B. Related Sections:
   1. 26 0553 - Identification for Electrical Systems

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
   2. NEMA FU 1 - Low Voltage Cartridge Fuses.
   3. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
   4. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.
   5. NEMA ICS 6 - Industrial Control and Systems: Enclosures.
   6. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. B. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

A. Provide submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.

1.4 QUALITY ASSURANCE

A. Equipment shall be of the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with the governing standards.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN

A. The Basis of Design is equipment from Square D by Schneider Electric to set a standard for quality. Equipment from alternative systems will be considered providing that sufficient documentation is provided to satisfy the CONTRACTING AGENCY that the equipment meets the requirements of the Specifications, and matches the Basis of Design on all points which are pertinent to the Project.

2.2 AC FRACTIONAL MANUAL STARTERS

A. The manual starter shall consist of a manually operated toggle switch equipped with melting alloy type thermal overload relay.

B. Thermal unit shall be one piece construction and interchangeable. Starter shall be inoperative if thermal unit is removed.

2.3 AC MANUAL STARTERS--LINE VOLTAGE TYPE

A. Manual starters shall be constructed and tested in accordance with the latest published NEMA standards.

B. The manual starters shall consist of a manually operated switch equipped with melting alloy type thermal overload relays in every phase conductor. Thermal units shall be one piece construction and the starter shall be inoperative if any thermal unit is removed.

C. Starters shall be furnished in a NEMA 1 general purpose enclosure unless otherwise indicated on the plans or required by the conditions of the area in which they are installed.

2.4 AC MAGNETIC STARTERS--LINE VOLTAGE TYPE

A. Motor starters shall be across-the-line magnetic type rated in accordance with NEMA standards, sizes and horsepower ratings.

B. Starters shall be mounted in NEMA 1 general purpose enclosures unless otherwise indicated on plans or required by the conditions of the area in which they are installed.

C. Starters shall be furnished with overload relays in every phase conductor and starters shall be inoperative if any overload unit is removed.
   1. Overload relays shall be bimetallic type. Thermal units shall be of one-piece construction and interchangeable.

D. Starters through NEMA size five (5) shall be equipped with double break silver alloy contacts. Contacts shall be replaceable without removing power wiring or removing starter from panel.

E. Coils shall be of molded construction and shall be 120 VAC. Starters shall have a fused 120V control power transformer in enclosure, or alternatively on 120/208 or 120/240 volt systems, the power system neutral conductor may be utilized. In all cases, control power shall be disconnected by the starter disconnecting means, unless otherwise specifically approved.

F. Starters shall be suitable for field addition of at least four (4) auxiliary electrical interlocks of any arrangement, normally open or normally closed.

G. Starters shall have enclosure mounted red running pilot light and Hand-Off-Auto switch.

2.5 AC COMBINATION STARTERS WITH FUSIBLE DISCONNECT SWITCH OR CIRCUIT BREAKER

A. Combination starters shall be manufactured in accordance with the latest published NEMA standards, sizes and horsepower ratings.

B. Disconnect switch combination starters shall consist of a visible blade disconnect switch and a motor starter.

C. Combination starters shall be mounted in NEMA 1 general purpose enclosures unless otherwise indicated on the plans or required by the conditions of the area in which they are installed.

D. The disconnect handle used on combination starters shall always be in control of the disconnect device with the door opened or closed. The disconnect handle shall be clearly marked as to whether the disconnect device is "on" or "off".

E. Magnetic starters provided under all Divisions of the Specifications shall be in accordance with this Section.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate details pertaining to the motor control equipment with the Division of these specifications where the equipment is specified.

3.2 CONTROL WIRING

A. Control wiring and control devices shall be provided under the Specification Division in which the controlled equipment is specified. Coordinate all related work.

3.3 CONNECTIONS

A. Provide liquid tight flexible conduit connections to motors and other equipment subject to vibration where LFMC is an acceptable wiring method. Provide flexible conduit connections to motors and other equipment subject to vibration that is located in spaces used for environmental air (e.g. fan rooms). Minimum length 12 inches.

3.4 NAMEPLATES

A. Provide engraved nameplates for all starters in accordance with Section 26 0553 – Identification for Electrical Systems. Coordinate names with mechanical equipment lists.

3.5 REDUCED VOLTAGE STARTERS

A. Reduced voltage starters shall be provided for all motors larger than:

208 volts	25 horsepower
460 volts	50 horsepower

1. This requirement shall apply to starters furnished in this Division and other Divisions of the specifications.
2. Motors controlled by Variable Frequency Drives (VFDs) are not subject to this requirement.

3.6 FIELD QUALITY CONTROL

A. Document each installation and operational step in accordance with approved shop drawings and manufacturer's requirements.

END OF SECTION 26 2900

SECTION 26 5000
LIGHTING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes general requirements, products and methods of execution relating to lighting fixtures, LEDs, LED drivers and related products approved for use on this project.

B. The Fixture Schedule is a general guide to type, quality and other characteristics. Fixtures of equal or better performance and quality may be substituted, subject to approval.

1.2 RELATED SECTIONS

A. 26 0529 – Hangers and Supports for Electrical Systems

B. 26 0533 – Raceway and Boxes for Electrical Systems

C. 26 2726 - Wiring Devices

D. 26 0919 - Enclosed Contactors

1.3 QUALITY ASSURANCE

A. The lighting fixtures shall be a standard catalog item as described on the Drawings and as made by a nationally recognized manufacturer.

1.4 SUBMITTALS

A. Provide submittals for all products in accordance with Section 26 0000 and Division 1.

B. Fixture mounting shall be clearly identified on submittal information and coordinated with architectural, features, assemblies, details and reflected ceiling plan.

C. Color selection for fixtures and fixture accessories shall be clearly identified on submittal information and coordinated with architectural.

1.5 SHOP DRAWINGS

A. Provide fabrication drawings that indicate fixture, type, kind, weight, LEDs, LED drivers, method of fitting and fastening parts together, location and complete details of method of suspension and fastening fixtures in place. Verify fixture dimensions with construction conditions prior to ordering fixtures.

B. Provide wiring diagrams that indicate supply power and interconnections for lighting controls, equipment, and light fixtures. Provide sufficient information to assemble and install equipment at the project site without further instructions.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within 60 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide fixtures in conformance with the Fixture Schedule, with all suspension, supports, flanges, trim, mounting, and operating accessories normally considered necessary for a complete, functional, and safe installation, whether specifically called for in the Contract Documents or not.

B. Linear fixture systems shall be provided with all corners, transitions, adjustable sections, custom angles, etc., to provide continuous linear systems.

2.2 LIGHT EMITTING DIODE (LED) FIXTURES

A. LED fixtures shall comply with Illuminating Engineering Society (IES) LM-79 guidelines and shall have a LM-79 photometric test report. Fixture shall utilize components (i.e. LEDs, driver, fixture housing, etc) included in LM-79 test.

B. LEDs shall comply with Illuminating Engineering Society (IES) LM-80 guidelines.

C. Fixture shall have lumen maintenance testing with minimum test duration of 10,000 hours.

D. Manufacturer stated end of life shall be at 70% light output. Operating life shall be no less than 50,000 hours.

E. Color temperature, and color rendering index (CRI) shall conform to the lighting fixture schedule shown on the Drawings.

F. Fixture components shall be lead free, mercury free and RoHS compliant.

2.3 FULLY RECESSED FIXTURES

A. Fixtures shall have thermal protection conforming to the NEC and shall be so identified.

B. Fixtures in direct contact with insulation shall be Type IC rated.

2.4 LED DRIVERS

A. Characteristics:
   1. Input: 120-277V (UL) AC, 50-60Hz
   2. Efficiency: >81% at full load
   3. Power Factor: >0.9 at full load
   4. Total Harmonic Distortion (THD): <20% at full load
   5. 0-10V compatibility
   6. Flicker-free dimming down to 1%

2.5 BATTERY POWERED EMERGENCY LIGHTING DRIVER – LED

A. Provide emergency battery driver for LED fixtures with the following features:
   1. Shall be capable of operating at the minimum lumen output specified on the Lighting Fixture Schedule for a minimum of 90 minutes
   2. Universal input (120-277 VAC)
   3. Compatible with the LED fixture and driver intended for use with.
   4. High-temperature long-life, nickel-cadmium battery or as approved. Electronic charger with 24 hour or less recharge time.
   5. Charge indicator lamp and test switch, with lamp visible, and test switch accessible, without opening fixture.
   6. UL listed.
   7. When used with dimmable drivers/fixtures circuity/programming to restore light output to specified lumens in emergency mode shall be provided.

2.6 FIXTURE ACCESSORIES

A. Canopies for pendant hung fixtures shall be of the ball joint type. Where more than one pendant is used per fixture, a ball joint fitting shall also be provided in the fixture end of each pendant.

PART 3 - EXECUTION

3.1 GENERAL

A. Drivers shall be installed per manufacturer's recommendations.

B. Fixtures with integral drivers shall have the driver installed and prewired at the factory.

C. Internal fixture wiring shall be factory installed in multiple fixtures which share a common driver. All wiring harnesses shall include an integral copper grounding conductor.

3.2 INSTALLATION

A. Install fixtures level, plumb and true. Align rows accurately in three dimensions.

B. Support suspended acoustical ceiling fixtures according to the requirements of the IBC and Section 26 0529 – Hangers and Supports as well as any local amendments.

C. Fixture pendants, canopies, blank sections, corners, tees and other such accessories shall be finished to match their respective fixture.

D. Refer to applicable details on architectural drawings for specific mounting requirements for all fixtures with special mounting requirements such as cove-mounted fixtures and linear fixtures.

E. For linear fixture systems, verify fixture dimensions and mounting type with other trades prior to installation.

F. Utility Rooms: Surface ceiling mount fixtures in rooms/areas with ceilings. In areas without ceilings pendant fixtures down to bottom of structure or height indicated on the Lighting Fixture Schedule. In areas with mechanical equipment, ductwork and piping, pendant fixtures down to bottom of mechanical ductwork or piping as appropriate. Fixture pendants shall be rigid (threaded hangar rods) and shall be sway braced where pendants exceed 24 inches in length.

G. Provide an unswitched circuit connection for the following (as applicable):
   1. Exit signs
   2. Emergency lighting units (ELUs)
   3. Emergency fixtures
   4. Emergency night lights
   5. Fixtures with emergency battery LED drivers

H. Wiring for fixtures connected to emergency circuits shall be kept entirely independent of all other wiring and equipment in accordance with NEC Article 700.

I. Clean all fixtures and lenses prior to substantial completion and owner occupancy.

3.3 FIRE-RESISTIVE CONSTRUCTION

A. Refer to Section 26 0000 Electrical General Requirements.

3.4 EXTERIOR FIXTURES

A. Exterior fixtures, supports and pole assemblies shall be capable of withstanding 100 mph winds with gusts to 130 mph with no damage. Where the Contracting Agency or any regulatory agencies require higher values for these, the more stringent requirements shall apply.

B. Anchor Bolts: Provide the quantity and type of anchor bolts required by the pole manufacturer. Provide flat-washers, lock-washers and hexagonal nuts. Provide template for positioning anchor bolts. All anchor bolts shall be hot dip galvanized.

C. Poles:
   1. Non-anodized poles shall be factory painted with polyester powder coat. Touch up all damage to paint.
   2. Anodized aluminum poles shall be finished with an Aluminum Association Architectural Class 1 anodized finish.

3.5 FLOODLIGHTING

A. Provide aiming points for all adjustable floodlighting. Permanently mark mounting equipment with final aiming orientations to facilitate later re-aiming after maintenance.

END OF SECTION 26 5000

SECTION 27 2010

TELECOM DISTRIBUTION SYSTEM (TDS)

PART 1 - GENERAL

1.1 DESCRIPTION AND GENERAL SPECIFICATIONS

A. Provide the equipment, materials, and labor to install the systems shown on the Drawings and specified herein. This shall include (but not be limited to) provision of all trenching and backfill, raceways, sleeves, boxes, gutters, shelves, enclosures, shelf and enclosure supports, backboards, equipment racks, line and low voltage wire and cable, patch cords, pull ropes (in unused conduits), terminal modules, panels, outlets, jacks, splices, connections, cable management, labeling, testing and all other material, equipment, and labor required to make the systems fully operational.

B. The intent of this Specification is to place in working order a complete, fully tested and documented Category 6 system complying with the Codes and Standards referenced herein.

1.2 CATEGORY RATED PERFORMANCE LEVEL

A. Category 6

1.3 RELATED SECTIONS

A. 26 0533 - Raceway and Boxes for Electrical Systems

1.4 COORDINATION

A. The necessity to coordinate this work with the Owner and the Contracting Agency is emphasized. The Contractor shall be responsible for any omissions, delays and additional cost due to lack of coordination or approval from the same.

B. Coordinate work with other contractors and trades. The layout and installation of the systems shown on the Drawings and specified herein shall be coordinated such that all special requirements for telecommunications systems shall be provided and incorporated into the project. The systems to be coordinated shall include (but are not limited to) electrical raceway, grounding, fire rated assembly, lighting, power distribution, control and instrumentation, and labeling of cables, terminations, outlets, jacks, etc. Report all conflicts to the Contracting Agency.

C. Downtime for existing systems shall be minimized. It is the responsibility of the Contractor to plan, coordinate, and execute installation activities so that facilities are not unduly interrupted. Periods of unavoidable interruption shall be less than 4 hours in duration and be prior approved by the Contracting Agency.

1.5 CODES AND STANDARDS

A. Where a Nationally Recognized Testing Laboratory (NRTL) listing or classification exists for a product and the product is suitable for the purpose specified and

indicated, the product shall bear the appropriate marking indicating the listing or classification.

B. Where a UL Standard is in effect, equipment shall:
   1. Meet that Standard.
   2. Bear the UL Label.

1.6 SUBMITTALS

A. The following shall be submitted in accordance with Section 26 0000 - Electrical General Requirements and Division 1 in sufficient detail to show full compliance with the specification:
   1. Manufacturer's Catalog Data shall be submitted for the following items. Data shall include a complete list of parts, special tools, and supplies.
      a. Copper Cable.
      b. Information Outlets.
      c. Patch Panels.
   2. Manufacturer's Installations Instructions.
   3. Labeling System: Coordinate with Contracting Agency for Owner's labeling conventions. Submit Project labeling system for approval.
   4. Contractor qualifications and experience as specified in this Section.
   5. Manufacturer's Warranty as specified elsewhere in this Section, including all warranty provisions and procedures for Owner to follow to obtain warranty service.

B. One copy of approved submittals shall be kept at the job site.

1.7 REFERENCE CODES AND STANDARDS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only, latest edition. The reference codes and standards are minimum requirements.

Reference	Title/Revision
ANSI/IEEE C2	National Electrical Safety Code
ANSI/NFPA 70	National Electrical Code
ANSI/TIA/EIA-568.0-D	Generic Telecommunications Cabling for Customer Premises
ANSI/TIA/EIA-568.1-D	Commercial Building Telecommunications Cabling
ANSI/TIA/EIA-568-C.2	Balanced Twisted-Pair Cabling and Components Standard.
ANSI/TIA/EIA-569-C	Commercial Building Standards for Telecommunications Pathways and Spaces
ANSI/TIA/EIA-606-C	Administration Standard for Commercial Telecommunications Infrastructure
ANSI/TIA/EIA-607-C	Commercial Building Grounding and Bonding Requirements for Telecommunications
ANSI/TIA-1152-A	

Reference	Title/Revision
BICSI	Telecommunications Distribution Methods Manual
ISO/IEC 11801-(1-6):2017	International Standard for Information Technology (Edition 3)
IEEE Std 1100	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (Emerald Book)
UL 1449	Transient Voltage Surge Protection
UL 1950	Standard for Information Technology Equipment, Including Electrical Business Equipment
UL 467	Grounding and Bonding Equipment
UL 497	Protectors for Paired Conductors for Communication Circuits
UL 497A	Secondary Protectors for Communication Circuits
UL 497B	Protectors for Data Communication and Fire Alarm Circuits
UL 910	Safety Test for Flame-Propagation and Smoke Density Values for Electrical and Optical- Fiber Cables

1.8 QUALIFICATIONS

A. The telecommunications work specified in this Section is acknowledged to require special skills mastered by education, experience, or both. Bidders for telecommunications work described in this Section shall be specialty telecommunications contractors, who may be a division of the Divisions 26 and 27 Subcontractor.

B. Contractor Certification:
   1. This subcontractor shall be a certified installer of the cabling system, pre-qualified by the Manufacturer for the purpose of offering the Extended System Warranty as required in this Section.
   2. Provide a signed statement indicating that the subcontractor has the ability to provide the service required by the Contract Documents using factory trained and qualified technicians for each major system type and intends to maintain that capability until the end of the guarantee period.

C. Contractor Experience:
   1. Specialty subcontractors bidding telecommunications work shall have a minimum of three years experience in the construction, testing, and servicing of systems of the type and magnitude specified herein.
   2. For each experience project submitted, provide the following information:
      a. Project name.
      b. Project location.
      c. Date of completion.
      d. Owner.
      e. Owner's representative and phone number.
      f. Description and dollar value of each installed system.
      g. Name and specific responsibility of each subcontractor or employee involved with the project.

3. For each experience project submitted, include a brief description of the system types provided and the name of the personnel directly responsible for the design (if required, and to what extent), specification, ordering, installation, programming, testing, demonstration, and overall system coordination for each of the following system types:
   a. Telecommunications General Requirements.
   b. Telecommunications Cable Pathway.
   c. Telecommunications Distribution System.
   d. Telecommunications Grounding.
   e. Telecommunications Identification and Labeling.
   f. Telecommunications Testing.

1.9 REGULATORY REQUIREMENTS

A. All Work shall conform to the requirements of NFPA 70 and all local amendments.

B. All Work shall conform to the requirements of all Federal, State and Local Electrical and Telecommunications Regulations.

1.10 SPECIAL WARRANTY

A. The warranty shall extend from the date of Substantial Completion to the longer of twenty (20) years or the length of the Extended Warranty offered by the successful manufacturer.

B. The warranty shall be extended to the Owner via the manufacturer through a single point of contact and shall be fully backed by the manufacturer.

C. The Extended Product Warranty and System Assurance Warranty for this wiring system shall be provided consisting of the following:
   1. Communications system components shall be rated for the end-to-end system performance levels on all pair combinations and warranted to support any existing or future applications which are designed to operate over a the Category rated performance levels noted in Part 2 of this specification as defined in ANSI/TIA/EIA 568.0-D.
   2. The Extended Product Warranty shall ensure against product defects, that the approved cabling components exceed the specification requirements of ANSI/TIA/EIA 568.0-D and ISO/IEC IS 11801-B, exceed the attenuation and NEXT requirements of ISO/IEC IS 11801-B for cabling links/channels, and that the installation will exceed the loss and bandwidth requirements of ISO/IEC IS 11801-B for links/channels. The warranty shall apply to passive Telecommunication Distribution System (TDS) components.
   3. The Extended Product Warranty and the System Assurance shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).
      a. In the event this specialty subcontractor is unable to perform, goes out of business or ceases to exist, the manufacturer shall be responsible for identifying a new contractor to assume the warranty work.
      b. Manufacturers shall bear full responsibility for the work of their certified installer, including applicable aspects of the design and installation.

c. In the event this specialty subcontractor fails to provide satisfactory warranty support, the manufacturer shall be responsible for taking the necessary remedial steps including finding a new contractor to provide warranty work.

D. Submit a summary of warranty highlighting major features. Clearly disclose exceptions to the requirements of this document, and specifically indicate any and the provisions that could potentially void the warranty or reduce its benefit to the Owner.

1.11 MANUFACTURERS' RECOMMENDATIONS

A. All installation procedures shall be in accordance with the recommendations of the manufacturer of the material being installed. Printed copies of these recommendations shall be submitted to the Contracting Agency 30 days prior to installation. Installation of the item shall not proceed until the recommendations are received and approved by the Contracting Agency. A copy of the recommendations shall be kept at the job site.

1.12 TERMINOLOGY

A. ANSI/TIA 568 shall refer to the latest adopted edition of ANSI/TIA-568.

B. The “Channel” is defined as the horizontal cabling and termination in the telecom room and workstation with the addition of patch and equipment cords at each location. The maximum patch cord length at the closet is 6 meters (20 ft.), and the maximum patch cord at the workstations is 3 meters (9.8 ft.). Channel testing must be done with the patch cords in place, and the cords cannot be removed after the testing is complete.

C. A “Link” is defined as the horizontal cabling between the telecom room termination and workstation termination. The termination at the closet and the workstation are included as part of the Basic Link. The maximum length that the horizontal cabling can be as defined in TIA/EIA is 90 meters (295 ft).

D. “TDS” shall refer to the Telecommunication Distribution System cabling and hardware infrastructure internal and external to a building or buildings used to transmit voice, video and data, etc.

E. "Stations" shall refer to individual telephone or computers, or remote peripherals of those systems (e.g., printers, facsimile machines, modems, etc.

F. "Outlets" shall refer to the group of receptacles or jacks at the location where the stations connect.

G. "Jacks" or "Ports" shall refer to the individual receptacles where phones, computers, etc. connect.

H. "Station Cables" shall refer to the horizontal cables connecting patch panels or terminal blocks in the Telecommunications Rooms to the stations.

I. “Pathways” shall refer to conduits, sleeves, cable-trays, distribution rings, etc., which are employed to route backbone and stations cables between equipment rooms, telecommunications rooms, stations, outlets, etc.

J. "Telecommunications Rooms (TR)" shall refer to a floor-serving facility for housing telecommunications equipment, cable terminations and cross-connect wiring. This is the point at which station cables terminate. It may also be referred to as an IDF.

K. "Terminal Blocks" shall refer to multiple punch down cable terminations.

L. “Patch Panels” shall refer to rack or frame mounted multiple punch down cable terminations with RJ-45 style, 8P8C jacks on the face for “plug and play” cross connect capability.

M. “Cable Management” shall refer to rings, troughs, gutters etc., mounted in conjunction with telecommunications distribution equipment and terminal blocks, for the orderly routing of cables, patch cords, etc.

1.13 STORAGE AND HANDLING

A. Care shall be exercised in handling materials during construction. Damaged materials shall be repaired or replaced as directed by the Contracting Agency.

PART 2 - PRODUCTS

2.1 GENERAL CABLE AND HARDWARE CHARACTERISTICS

A. Materials shall be as specified, first quality, manufacturer’s current production.

B. Products shall provide the standard of performance required under Section 2.2 of this specification and the Special Warranty above.

C. Cable
1. General
   a. Horizontal telecommunication cables shall be extended between the station location and its associated TR and shall consist of 4 pair, 22, 23, or 24 gauge (as required by the Category performance rating noted below), UTP, and shall be terminated on the 8 pin modular jacks provided at each outlet. Provide cables with four FEP insulated conductor pairs (4/0 configuration).
   b. Cables shall conform to the ANSI/TIA/EIA 568-D Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section, and be part of the UL LAN Certification and Follow-up Program.
2. Plenum rated – UL CMP
3. UL or ETL Verified for the Category electrical performance level in noted in Part 1.
4. UL Listed for Fire Safety.
5. ISO 9001 Certified Manufacturer.
6. Environmental:
   a. Storage temperature: 68° F to 122° F (20° C to 50° C).
   b. Installation Temperature: 32° F to 122° F (0° C to 50° C).
   c. Operating Temperature: 14° F to 140° F (-10° C to 60°).

D. Information Outlet/Jacks
   1. Faceplates
      a. Configure single gang outlet information outlets in single, duplex, triplex, or quad-plex arrangement, as required for the installation.
      b. Provided blank module inserts for unused module locations.
      c. Provide full set of color-coded snap-in icons for workstation outlets for use by Owner to mark jacks for analog and digital telephones, two unique classes of data, etc. Store icons in clear plastic bags in each TR.
      d. Refer to Specification Section 26 2726 - Wiring Devices for faceplate type/color.
   2. Outlets/Jacks
      a. Telecommunications jacks shall consist of multi-position 8-pin modular (8P8C) jacks, utilizing T568A style.
      b. Jacks shall be manufactured by the same manufacturer as the modular patch panels.

E. Patch panels
   1. Modular jack panels shall be in 24 or 48 port configurations as shown on the Drawings. Modular jack panels installations shall contain a retaining trough between every panel. Modular jack panels shall be wired for T568A configuration.
   2. Designation labels for each jack shall be provided for front/rear labeling of each patch panel. All cables shall be terminated in numerical sequence and labeled as to outlet number and jack position (A, B, C, D). Provide color-coded inserts ("icons") for populated jacks at patch panels and at each outlet.

2.2 CATEGORY RATED CABLE AND HARDWARE PERFORMANCE CHARACTERISTICS

A. Category 6
   1. Horizontal telecommunication cables, telecommunication outlets/jacks, telecommunication patch panels, and patch cords:
      a. Shall meet or exceed the Channel performance defined by ANSI/TIA/EIA-568-D for a Category 6 rated system.
      b. Shall be UL or ETL Verified for ANSI/TIA/EIA 568-D Electrical Performance for a Category 6 rated system.

2.3 CATEGORY RATED CABLE AND HARDWARE EQUIPMENT

A. CATEGORY 6
   1. Horizontal telecommunication cables, telecommunication outlets/jacks, telecommunication patch panels, and patch cords:
      a. Performance characteristics meeting or exceeding those specified in ANSI/TIA 568 (latest adopted edition) Category 6 requirements between 1 and 250 MHz.

2.4 LABELING

A. Provide machine printed labels for all patch panels, cables, outlets, etc., in accordance with ANSI/TIA/EIA-606-A. Provide labeling nomenclature in accordance with information on the Drawings or Owner's labeling conventions. Submit labeling samples for all required applications.

B. Labeling and color coding identification for this project shall conform to TIA/EIA-606-A for a Class 1 Administrative System.

2.5 UNSPECIFIED EQUIPMENT AND MATERIAL

A. Any item of equipment or material not specifically addressed on the Drawings or in this document and required to provide a complete and functional TDS installation shall be provided in a level of quality consistent with other specified items.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide, connect and test all equipment and materials for the systems herein specified and shown on the Drawings. All wiring shall be neatly tied or laced in cabinets and terminated on terminal strips provided for the purpose. Each cable shall be identified by an approved marking system at each end.

B. Outlet/Jacks shall be identified with machine printed labels. Hand lettered labels shall not be used.

C. Provide labels and color-coded inserts for each jack at patch panels, in accordance with TIA/EIA-606-A.

D. Wherever materials, methods or placements of materials and equipment for the communications work is provided by other Subcontractors or the Owner, it shall be the responsibility of this specialty Subcontractor to coordinate that work and assure that it is provided in such a manner as to enhance the final system operation.

E. Test the systems, demonstrate operation to the Contracting Agency and provide training as specified.

F. Work under this section shall be closely coordinated with work under other sections of the project.

3.2 CODES AND PERMITS

A. Apply and pay for all fees, permits, and obtain serving utility and governmental approvals.

B. Coordinate all work with the serving utility.

C. Raceway fill requirements for communications systems shall be in accordance with ANSI/TIA/EIA-569-A and BICSI.

D. NEC bending radius of all communications ducts, raceways, cabletrays, etc., shall be increased to not less than the installed cable manufacturer's recommendations, and the applicable ANSI and BICSI Standards.

E. Communications work shall be in complete accordance with the following:
   1. National Electrical Code (NEC), latest legally enacted edition.
   2. Regulations of the State Fire Marshal.

3. National Fire Protection Association (NFPA) Codes.
4. All state, county and local codes and ordinances.

3.3 DELIVERY AND STORAGE

A. Materials and Equipment shall be stored with protection from mechanical damage, weather, humidity and temperature variation, dirt and dust, and other contaminants.

B. Materials shall be inspected and inventoried promptly upon receipt.

C. Cables shall be tested immediately upon receipt and received or rejected and returned based upon testing or visual inspection.

D. Report and record all serial numbers received and/or rejected.

3.4 LAYOUT

A. All work shall be laid out in advance. Cables shall be racked and supported in a workmanlike fashion. All work shall be labeled according to ANSI/TIA/EIA 606-A, and color coded according to BICSI Standards. In the absence of details on the drawing governing the layout of terminations, the following guidelines shall apply.
   1. All horizontal cables from a common outlet shall terminate sequentially (in groups) on the same patch panel unless the cables are of different performance levels such as Category 5e and 6.
   2. Horizontal cables that are of different performance levels, such as Category 5e and 6, shall be terminated on different patch panels, and identified accordingly.
   3. Pairs from each cable shall be terminated sequentially from left to right, top to bottom starting with the lowest assigned number at the upper left hand corner of the frame.

B. Keep up to date "As-built" record drawings at each job site detailing the layout of all data racks and telephone, data and trunk terminations, including a typed listing of cables/rooms served by each terminal block and patch panel. Refer to Section 26 0000 - Electrical General Requirements for other Record Document requirements.

3.5 CABLE INSTALLATION

A. Cable shall be installed in conduit routed to directly to Telecommunication Rooms or via conduit stubbed to cable tray.

B. If cable dimensions shown are exceeded, all cable pathways and supports shall be resized to maintain the original fill ratios based on the dimensions shown.

C. Follow cable manufacturer’s specification regarding handling methods, retaining/support methods, bending radius and maximum pulling tension limitations.

D. Telecommunication cables shall not be installed in the same raceway as power cables.

E. Cables shall be installed in a neat and orderly manner and shall not cross or interlace other cables except at breakout points.

F. Cables in vertical trays shall be individually retained with straps at a maximum of 6 feet on center.

G. Tie wraps shall not deform the cable insulation when tightened.

H. All cables shall be routed to minimize EMI and RFI interference. All cable shall be routed according to the following table. Spacings are minimum for all Category 3 and higher cable.

Minimum Separation of Telecommunications pathways from 480 volt or less power lines

Condition	<2 kVA	2-5 kVA	>5 kVA
Unshielded power lines or electrical equipment in proximity to telecommunications open or nonmetal pathways.	5 in	12 in	24 in
Unshielded power lines or electrical equipment in proximity to telecommunications grounded metal conduit pathways	2.5 in	6 in	12 in
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a telecommunications grounded metal conduit pathway	N/A	3 in	6 in
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to telecommunications open or nonmetal pathways.	2.5 in	6 in	12 in
Mechanical ductwork, metal floors and other metallic planes to telecommunications open or nonmetal pathways.	2 in		
Mechanical ductwork, metal floors and other metallic planes to telecommunications open or grounded metal conduit pathways.	0 in		
Fluorescent or HID lighting fixtures	5 in	5 in	5 in

3.6 DAMAGE AND DEFECTS

A. Cable shall be carefully inspected for sheath defects or other irregularities as it is paid out form the reel. When defects are detected, pulling shall stop immediately and the cable section shall be repaired or replaced at the discretion of the Contracting Agency. A system of communications shall be maintained between pulling and feed locations so that pulling can be stopped instantly, when required.

B. Adequate care shall be exercised when handling and storing reels of cable to prevent damage to the cable. Cable with dents, flat spots, or other sheath distortions shall not be installed.

3.7 TERMINATIONS

A. Cables shall be marked with wire markers at both ends, and terminals on terminal blocks or patch panels shall bear the cable number. Trunk cables shall be neatly marked with "From-To" information.

B. Wire twist shall be maintained to within 0.25 inch of the termination.

3.8 COMPLETION AND TESTING

A. Telecommunications System test reports shall be submitted to and approved by the Contracting Agency. The test reports shall certify that the Telecommunications Distribution System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.

B. After installation and test of each system is complete, each system and the entire system shall be demonstrated and tested for proper operation. The Contractor shall schedule a demonstration with the following representatives present:
   1. Contractor's representative.
   2. Manufacturer's representative for each major communications subsystem.
   3. Contracting Agency's representative.

C. The Contractor shall provide all forms, instrumentation and test equipment, loads, and other consumables required to demonstrate the systems to the Contracting Agency’s satisfaction.

D. Incoming Inspection Tests:
   1. Inspect all materials for damage.

E. Final Inspection Tests:
   1. Testing of all copper wiring shall be performed prior to system acceptance. 100 percent of the horizontal and riser wiring pairs shall be tested. Link testing of all copper cabling shall be performed. Complete, end to end test results shall be submitted to the Contracting Agency.
      a. Category 6 cable runs shall be tested for conformance to the specifications of EIA/TIA 568-B.2, Category 6. Testing shall be done with a ANSI/TIA/EIA 568-B ETL verified Level II-E test set, with accuracy per Proposed TIA Level III standards.
         1). Test shall include all requirements of ANSI/TIA/EIA 568-B, including wiremap, length, characteristic impedance, insertion loss, ambient and impulse noise, NEXT, PSNEXT, FEXT, ELFEXT, PSELFEXT, return loss, ACR, PSACR, Propagation Delay and Delay Skew.
         2). Supported test frequency shall be 1-350 MHz to provide re-certification capability beyond Category 6 requirements.
         3). “Full Plot” storage shall store entire test, and be capable of uploading saved data and re-characterizing cables against new or evolving performance standards. Testers only saving worst case data are not

acceptable. Test data shall be saved and provided to the Owner in neatly bound hardcopy and electronic format compatible with ScopeData Pro® software. Provide a copy of the software with the data.

4). Reports shall be graphic, showing test results plotted against standards. Reports shall include a pass/fail summary of all network types specified.

5). Any cables not meeting the requirements of the standard shall be brought into compliance at no charge to the Owner.

6). Tester shall be equal to Agilent Technologies (HP) WireScope 350, Fluke DSP-4000, or IDEAL LANTEK 6P.Test all cable with an approved cable tester in the presence of the Contracting Agency, at the Contracting Agency's option. Provide three (3) working days advance notice of tests. Record cable numbers on data test reports. Submit reports to Contracting Agency.

3. Test all cables from both ends.
4. Re-test all cable disturbed after testing, at the direction of Contracting Agency.
5. Spare unterminated cable shall be temporarily terminated for testing.

F. Replace all rejected materials.

G. Test AC grounds and voltages in equipment racks.
   1. Record voltage at equipment rack power source both at no load and at 15 Amp resistive load.

3.9 FIELD QUALITY CONTROL

A. Document each installation and operational step in accordance with approved shop drawings and manufacturer's requirements.

END OF SECTION 27 2010

SECTION 32 1000
EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Requirements for site work shown on the Drawings.

1.2 RELATED SECTIONS

A. General Conditions of the Construction Contract.

B. Division 32 Sections for landscaping sitework.

1.3 REFERENCED SPECIFICATIONS

A. This contract is subject to and hereby incorporates by reference the following documents as though physically contained herein:
   1. Sections of the Municipality of Anchorage Standard Specifications, 2015 Edition, as enumerated below, with modifications as contained herein. This document is herein referred to as M.A.S.S.
   2. Alaska Sign Design Specifications, effective 1/23/2015.
   3. The Municipality of Anchorage, Design Criteria Manual, January 2007.
   4. The Municipality of Anchorage, Anchorage Stormwater Manual (FINAL).

B. When conflicts exist between M.A.S.S., the MUTCD, and other referenced documents, the requirements of M.A.S.S. and the modifications contained herein shall govern.

C. When conflicts exist between M.A.S.S. and the Project Specifications, the Project Specifications shall govern.

D. Where an item of Work not addressed by the Project Specifications, but addressed by M.A.S.S., then the item of Work shall be in accordance with M.A.S.S., regardless of whether or not the M.A.S.S. Section of relevance is specifically enumerated herein.

E. The incorporated reference documents are available from the following sources. Contact the listed source for current document fees.
   1. M.A.S.S., Municipality of Anchorage Project Management and Engineering Department, http://www.muni.org/Departments/project_management/Pages/MASS.aspx
   2. Municipality of Anchorage Sign Manual – Municipality of Anchorage Traffic Department, http://www.muni.org/Departments/traffic/Pages/Safety.aspx
   3. Alaska Supplement – State of Alaska, Department of Transportation & Public Facilities, Design and Engineering Services, http://www.dot.state.ak.us/stwddes/

F. All references to “Municipality of Anchorage” shall mean “Owner”. All references to “Engineer” shall mean “Owner’s Representative”.

G. This Specification section applies only to the Drawings designated as site and landscape plans.

1.4 MUNICIPALITY OF ANCHORAGE STANDARD SPECIFICATIONS, 2015, HEREIN REFERRED TO AS "M.A.S.S.".

A. Division 10.00 – Standard General Provisions
   1. Section 10.1 Definitions
   2. Section 10.04, Article 4.3: Submittal List
   3. Section 10.04, Article 4.7: Reference Stakes and Surveying
   4. Section 10.04, Article 4.8: Work Incidental to the Contract
   5. Section 10.04, Article 4.9: Disposal Sites
   6. Section 10.04, Article 4.10: Protection of Persons, Property and Environment
   7. Section 10.04, Article 4.13: Traffic Control Plan
   8. Section 10.04, Article 4.14: Maintenance and Drainage
   9. Section 10.04, Article 4.15: Temporary Erosion Control and Storm Water Pollution
   10. Prevention Plans for Construction.
   11. Section 10.04, Article 4.19: Record Documents
   12. Section 10.05, Control of Work
   13. Section 10.06, Article 6.6: Permits
   14. Section 10.06, Article 6.8: Safety

B. Division 20.00 - Earthwork
   1. Section 20.01: General
   2. Section 20.02: Storm Water Pollution Prevention Plan (Type 1)
   3. Section 20.09: Removal of Pavement
   4. Section 20.21: Classified Fill and Backfill
   5. Section 20.22: Leveling Course

C. Division 30.00 - Portland Cement Concrete
   1. Section 30.01: General
   2. Section 30.02: Portland Cement Concrete, Curb and Gutter and Valley Gutter
   3. Section 30.09: Concrete Parking Bumpers

D. Division 40.00 - Asphalt Surfacing
   1. Section 40.11: Remove and Replace Asphalt Surfacing

E. Division 65.00 – Construction Surveys
   1. Section 65.01: General
   2. Section 65.02: Construction Surveying

F. Division 70.00 - Miscellaneous
   1. Section 70.01: General
   2. Section 70.10: Traffic Markings
   3. Section 70.11: Standard Signs

G. Add the following Section:
   1. Section 70.21: Wood Screen Fence

H. Standard Details as Listed Below:
   1. 20-14 TYPE II-A CLASSIFIED FILL AND BACKFILL

2. 20-18 LEVELING COURSE
3. 30-1 CURB AND GUTTER CROSS SECTIONS (TYPE 3)
4. 40-2 TYPICAL RESURFACING DETAIL NON-GRAVEL SURFACES
5. 70-31 CONCRETE FOUNDATION FOR SIGNPOST

1.5 SUBMITTALS

A. Type II-A Classified Fill, and Leveling Course
   1. Particle-size Analysis

B. Exterior Portland Cement Concrete for curbs
   1. Mix Design
   2. Certificate of Compliance for Curing Compound and Admixtures
   3. Compressive strength
   4. Slump Test Results (Performed by Contractor)

C. Asphalt
   1. Mix Design

D. Traffic Markings
   1. Paint manufacturer's cut sheet and application recommendations
   2. Method of paint removal

E. Wood Screen Fence
   1. Wood product information
   2. Stain product information/cut sheet

F. Record Drawing
   1. Indicating improvements with location and dimensions including utilities.

1.6 MODIFICATIONS AND/OR ADDITIONS TO M.A.S.S.

A. All Divisions, All Sections: Delete articles entitled "Measurement" and "Basis of Payment."

B. Testing shall be incidental to the contract. The Contractor shall be responsible for all certifications and their own quality control.

C. Modify the MASS Sections and Articles as follows: Division 10.00 - Standard General Provisions
   1. Section 10.04, Article 4.7: Reference Stakes and Surveying
   2. Delete the first paragraph and replace with the following:
   3. Benchmarks and/or reference point have not been identified and/or placed. The Contractor shall identify property lines as a part of initial layout of improvements.
   4. Section 10.04, Article 4.13: Traffic Control Plan

D. Add the following:
   1. The contractor shall conduct operations to minimize interference to onsite use of the parking areas not impacted by construction, access to building entrances and exists, and pedestrian and vehicle access to rights-of-way. Provide a plan to the owner showing extent of area needed for conducting the Work and timeframes for closures of parking spaces.

2. Section 30.01, Article 1.8: Sampling and Testing

E. Delete the first two paragraphs and replace with the following:
   1. The Contractor shall take concrete samples for concrete cylinders in accordance with AASHTO T-141. Samples shall not be taken at the beginning or end of discharge. Making and curing the specimens shall be done in accordance with AASHTO T-23. Testing and sampling shall be done by the Contractor.
   2. Slump test shall be taken in accordance with AASHTO T-119 or AASHTO C-143. Slump tests shall be taken by the Contractor and results shall be provided to the Owner's Representative.
   3. Section 30.02, Article 2.3: Construction

F. Add the following:
   1. Installation of new curb and gutter shall include the replacement of 12" of subgrade with Type II-A Classified backfill. Type II-A material and compaction shall conform to Section 20.21.
   2. Section 40.11: Remove and Replace Asphalt Surfacing
   3. Article 11.1 Description

G. Add the following:
   1. See Division 40 for related material and construction specifications.
   2. Article 11.3 Construction

H. Replace the second paragraph with the following:
   1. Contractor shall remove existing asphalt surfacing and leveling course, regardless of thickness, as needed to install the proposed curb and gutter and improvements along the west property line. Replacement asphalt shall be 2-inches thick, leveling course shall be a minimum of 2-inches thick or greater as needed to achieve necessary grades.

I. Add the following Section:
   1. Section 70.21 Wood Screen Fence
   2. Article 13.1 General
   3. Work under this Section includes but is not limited to all labor, materials, transportation, and maintenance necessary to furnish and install a Wood Screen Fence as shown on the Drawings and as specified herein.
   4. Utility Coordination: The Contractor is responsible for the verification of all existing utilities and requesting locates of underground utility lines.
   5. Delivery, Storage, and Handling: Store materials to permit east access for inspection and identification. Keep wood and hardware clean and free from water.

   6. Article 13.2 Materials
      a. Wood
         1). Grading Rules: Standard and dressing rules if the West Coast Lumber Inspection Bureau of the Western Wood Product Association. Each piece of yard and structural lumber shall bear official grade mark of the appropriate bureau or association. Provide Standard or better Western Red Cedar No 2 & Better, surfaced four (4) sides, and kiln dried. Moisture content shall not exceed nineteen percent (19%).

b. Pressure Treated Posts:
   1). All pressure treated wood shall be approved for residential use by the EPA and shall not contain toxic chemicals such as arsenic and creosote, it shall be appropriate for in-ground use. Contractor shall submit a certificate of treatment to the Owner's Representative for approval prior to use on the Project.
      i. After treatment, wood shall be clean, of natural colors and finish, non-corrosive, water repellent, paintable, odorless, dry and non-staining.
   2). Cedar Finish: Thompson's Water Seal Timber Oil transparent stain in 'cedar' color.
c. Concrete:
   1). Portland cement shall be Class A-3.
   2). Top of concrete shall be slopes to drain water away from wood post
d. Hardware:
   1). Hardware shall be appropriate for exterior use and be stainless steel or hip-dipped galvanized finish as indicated on the Drawings.

7. Article 13.3 Construction
   a. Preparation: the contractor shall layout fence footings as to not interfere with existing utilities or signpost footings existing or proposed.
   b. Installation: Slope drainage of concrete footing away from wood post. Posts shall be plumb and level with a consistent height across the fence per the Drawings. Install wood members with necessary fasteners consistent with Drawings.
   c. Once installed finish cedar wood with stain in accordance with product instructions.

PART 2 - PRODUCTS

2.1 SEE REFERENCED M.A.S.S. SECTIONS FOR MATERIALS.

PART 3 - EXECUTION

3.1 SEE REFERENCED M.A.S.S. SECTIONS FOR CONSTRUCTION.

END OF SECTION

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SECTION 32 9000

PLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Planting and landscape site improvements including and not limited to planting, topsoil, landscape products, maintenance, and plant establishment.

1.2 REFERENCE SPECIFICATIONS

A. This contract is subject to and hereby incorporates by reference the following documents as though physically contained herein:
   1. Sections of the Municipality of Anchorage Standard Specifications, 2015 Edition, as enumerated below, with modifications as contained herein. This document is herein referred to as M.A.S.S.
   2. The Municipality of Anchorage, Design Criteria Manual, January 2007.
   3. The Municipality of Anchorage, Anchorage Stormwater Manual (FINAL).

B. When conflicts exist between M.A.S.S. and the Project Specifications, the Project Specifications shall govern.

C. Where an item of Work not addressed by the Project Specifications, but addressed by M.A.S.S., then the item of Work shall be in accordance with M.A.S.S., regardless of whether or not the M.A.S.S. Section of relevance is specifically enumerated herein.

D. The incorporated reference documents are available from the following sources. Contact the listed source for current document fees.
   1. M.A.S.S., Municipality of Anchorage Project Management and Engineering Department, http://www.muni.org/Departments/project_management/Pages/MASS.aspx

E. All references to “Municipality of Anchorage” shall mean “Owner”. All references to “Engineer” shall mean “Owner’s Representative”.

F. This Specification section applies only to the site and landscape designated Drawings.

1.3 MUNICIPALITY OF ANCHORAGE STANDARD SPECIFICATIONS, 2015, HEREIN REFERRED TO AS “M.A.S.S.”.

A. Division 75.00 – Landscape Improvements
   1. Section 75.01: General
   2. Section 75.02: Landscaping
   3. Section 75.03: Topsoil
   4. Section 75.06: Landscape Edging
   5. Section 75.07 Landscape Fabric

B. Add the following Sections:
   1. Section 75.12: Moose Protection Fence

1.4 SUBMITTALS

A. Landscaping
   1. Plant list with common and scientific species names, quantities, sizes, source, plant certifications as required by state and federal laws.
   2. Shredded bark mulch source and material specification description.
   3. Maintenance and Watering schedule
   4. Fertilizer certificate

B. Topsoil
   1. Soil analysis report

C. Aluminum edging
   1. Product cut sheet

D. Landscape Fabric
   1. Product cut sheet

1.5 MODIFICATIONS AND/OR ADDITIONS TO M.A.S.S.

A. All Divisions, All Sections: Delete articles entitled “Measurement” and “Basis of Payment.”

B. Modify the MASS Sections and Articles as follows:
   1. Division 75 – Landscaping Improvements
   2. Section 75.02: Landscaping
   3. Article 2.2 Materials, Subsection B

C. Delete the following:
   1. Item “1. Wood Chips”

D. Add the following to Item 2. Shredded Bark Mulch:
   1. Shredded bark mulch shall be installed to a 3” depth throughout bed as indicated on the drawings with four-to-six-inch (4” to 6”) space around the base of all tree trunks, shrub bases, and perennials.

E. Replace Item 3 with the following:
   1. 3. Rock Mulch
      a. Rock mulch shall be 2” washed river rock, Seward black, uniform in size and color. All fines shall be screened from the rock within a one-quarter inch (1/4”) tolerance. Rock mulch shall be composed of round rocks in uniform color. The material shall be free of organic and inorganic debris and trash.
   2. Article 2.3 Construction

F. Add the following:
   1. S. Restore Surfaces: Any surface disturbance outside of proposed improvements shall be restored to match previous surfacing to a stable clean condition. If surface was previously lawn the are shall be restored with topsoil and sod, if the surface is landscape mulch the surface shall be restored to match mulch in a equivalent or improved condition.
   2. Section 75.03: Topsoil
   3. Article 3.3 Placing

G. Replace paragraph four with the following:

1. Topsoil in planting beds shall be at the depth shown on the Drawings, at a minimum of eighteen inches (18") throughout beds. Planting beds shall be free of compact fill or subgrade prior to backfilling with topsoil.
2. Section 75.07: Landscape Fabric
3. Article 7.3 Construction

H. Replace the first paragraph with the following:
   1. Landscape fabric shall be installed at locations with rock mulch as shown on the Drawings. Landscape fabric shall not be visible under rock mulch and all loose ends shall be cut off, tucked under, or otherwise covered with rock mulch by the Contractor. Landscape fabric shall be in direct contact with soil. Landscape fabric shall not be installed in landscape beds with shredded bark mulch.

I. Add the following Section:
   1. Section 75.12 Moose Protection Fence
   2. Article 12.1 General
      a. Work under this Section includes all equipment, labor, and transportation necessary to furnish, install, and remove Moose Protection Fencing as specified herein. Moose Protection Fencing is required around all new individual deciduous trees and/or deciduous tree groupings. Moose Protection Fences are to be removed at the completion of the plant establishment period, unless otherwise directed by the Owner's Representative. The Owner's Representative may notify the Contractor about damages to the Moose Protection Fencing, in which case the repairs shall be made within two (2) working days. The Contractor shall repair and replace all materials damaged or destroyed within the scope of the Work, regardless of cause.
   3. Article 12.2 Materials
      a. Fabric: 1"x2" welded wire mesh. Min. 14-gauge wire diameter. 5' height with 1x1.5-inch maximum opening. Use metal ties to secure to posts.
   4. Steel T-Posts: 9' height, green steel T-posts with pointing with safety caps.
   5. Article 12.3 Construction
      a. Workmanship and Procedure: Moose protection fencing shall be erected immediately following the tree installation. The moose protection fencing shall be placed at the outside edges of individual deciduous trees and/or deciduous tree groupings. All deciduous trees shall be enclosed within the fencing without damaging branches or allowing branches to protrude. The fencing shall remain in place during the duration of the Work and shall be removed at the end of the Plant Establishment Period.

PART 2 - PRODUCTS

2.1 SEE REFERENCED M.A.S.S. SECTIONS FOR MATERIALS.

PART 3 - EXECUTION

3.1 SEE REFERENCED M.A.S.S. SECTIONS FOR CONSTRUCTION.

END OF SECTION

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