TABLE OF CONTENTS

DIVISION 01, 11, 23, 26, 27, 28 – PROJECT NIST SPECIFICATIONS

01 33 00	SUBMITTAL PROCEDURES
01 78 23	OPERATION AND MAINTENANCE DATA
11 53 13	LABORATORY FUME HOODS AND RELATED PRODUCTS
23 05 53	IDENTIFICATION FOR HVAC AND LAB EQUIPMENT
23 05 93	TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 31 13	PVC LABORATORY EXHAUST DUCTWORK
23 34 16	UTILITY SET FANS
26 00 10	GENERAL ELECTRICAL REQUIREMENTS
26 05 00	COMMON WORK RESULTS FOR ELECTRICAL
26 05 02	EQUIPMENT WIRING SYSTEMS
26 05 19	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 26	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 29	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 05 33	RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
26 05 44	SLEEVES AND SLEEVES SEALS FOR ELECTRICAL SYSTEMS
26 05 48	VIBRATION CONTROLS FOR ELECTRICAL SYSTEMS
26 05 53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 27 26	WIRING DEVICES
26 27 33	POWER DISTRIBUTION UNITS
26 28 13	FUSES
26 28 16	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
26 41 13	LIGHTNING PROTECTION FOR STRUCTURES
27 05 26	GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEM
27 05 28	CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
28 31 13	FIRE ALARM SYSTEM

SITE SPECIFIC DOCUMENTS:

NIST CONDUIT COLOR CHART
NIST EQUIPMENT LIST AND EQUIPMENT ID
NIST ELECTRICAL SITE STANDARDS

END OF DIVISION 01, 11, 23, 26, 27, 28 TABLE OF CONTENTS

SECTION 013300 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require project COR responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require project COR responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

1.3 SUBMITTAL SCHEDULE

A. Submittal Schedule: Submit, as an action submittal, a list of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by project COR and additional time for handling and reviewing submittals required by those corrections.

1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.
2. Initial Submittal: Submit concurrently with startup construction schedule. Include submittals required during the first 60 days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
3. Final Submittal: Submit concurrently with the first complete submittal of Contractor's construction schedule.

    a. Submit revised submittal schedule to reflect changes in current status and timing for submittals.

4. Format: Arrange the following information in a tabular format:

    a. Scheduled date for first submittal.
    b. Specification Section number and title.
    c. Submittal Category: Action; informational.
    d. Name of subcontractor.
    e. Description of the Work covered.

1.4 SUBMITTAL FORMATS

A. Submittal Information: Include the following information in each submittal:

1. Project name.
2. Date.
3. Name of Contractor.
4. Name of firm or entity that prepared submittal.
5. Names of subcontractor, manufacturer, and supplier.
6. Unique submittal number, including revision identifier. Include Specification Section number with sequential alphanumeric identifier; and alphanumeric suffix for resubmittals.
7. Category and type of submittal.
8. Submittal purpose and description.
9. Number and title of Specification Section, with paragraph number and generic name for each of multiple items.
10. Drawing number and detail references, as appropriate.
11. Indication of full or partial submittal.
12. Location(s) where product is to be installed, as appropriate.
13. Other necessary identification.
14. Remarks.
15. Signature of transmitter.

B. Deviations and Additional Information: On each submittal, clearly indicate deviations from requirements in the Contract Documents, including minor variations and limitations; include relevant additional information and revisions, other than those requested by the project COR on previous submittals. Indicate by highlighting each submittal or noting on attached separate sheet.

C. PDF Submittals: Prepare submittals as PDF package, incorporating complete information into each PDF file. Name PDF file with submittal number.

D. Submittals for Web-Based Project Software: Prepare submittals as PDF files.

1.5 SUBMITTAL PROCEDURES

A. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Web-Based Project Software: Prepare submittals in PDF form, and upload them to web-based Project software website administered by the project COR.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.

3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of submittals for related parts of the Work specified in different Sections so processing will not be delayed because of need to review submittals concurrently for coordination.

    a. Project COR reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation.

D. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

1.6 SUBMITTAL REQUIREMENTS

A. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are unsuitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.

4. For equipment, include the following in addition to the above, as applicable:

    a. Wiring diagrams that show factory-installed wiring.
    b. Printed performance curves.
    c. Operational range diagrams.
    d. Clearances are required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before Shop Drawings, and before or concurrent with Samples.

B. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

C. Fume Hood Testing Reports:

1. Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of fume hood balancing and ANSI/ASHRAE 110: Laboratory Fume Hoods Performance Testing performed after installation of the fume hood.

1.7 CONTRACTOR'S REVIEW

A. Action Submittals and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to the project COR

B. Contractor's Approval: Indicate Contractor's approval for each submittal with a uniform approval stamp. Include name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

1.8 PROJECT CO AND COR REVIEW

A. Action Submittals: The project CO and COR will review each submittal, indicate corrections or revisions required.

B. Informational Submittals: The project CO and COR will review each submittal and will not return it or will return it if it does not comply with requirements.

C. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013300

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.3 CLOSEOUT SUBMITTALS

A. Submit operation and maintenance manuals indicated. Provide content for each manual as specified in individual Specification Sections, and as reviewed and approved at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. The project CO and COR will comment on whether content of operation and maintenance submittals is acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

B. Format: Submit operation and maintenance manuals in the following format:

1. Submit by uploading to web-based project software site. Enable reviewer comments on draft submittals.

C. Initial Manual Submittal: Submit draft copy of each manual at least 30 days before commencing demonstration and training. The project CO and COR will comment on whether general scope and content of manual are acceptable.

D. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. The project CO and COR will return copy with comments.

1. Correct or revise each manual to comply with the project CO and COR comments. Submit copies of each corrected manual within 15 days of receipt of the project CO and COR comments and prior to commencing demonstration and training.

1.4 FORMAT OF OPERATION AND MAINTENANCE MANUALS

A. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Bookmark individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

B. Manuals, Paper Copy: Submit manuals in the form of hard-copy, bound and labeled volumes.

1. Quantity: 1 sets of paper O&M manuals

2. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

   a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
   b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.

3. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
4. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment. Enclose title pages and directories in clear plastic sleeves.
5. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.
6. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

1.5 SYSTEMS AND EQUIPMENT OPERATION MANUALS

A. Systems and Equipment Operation Manual: Assemble a complete set of data indicating operation of each system, subsystem, and piece of equipment not part of a system. Include information required for daily operation and management, operating standards, and routine and special operating procedures.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

B. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor has delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Wiring diagrams.
6. Control diagrams.
7. Piped system diagrams.

C. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

D. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

10.

1.6 PRODUCT MAINTENANCE MANUALS

A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

B. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

C. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

D. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

E. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

F. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

G. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 017823

SECTION 115313 – LABORATORY FUME HOODS AND RELATED PRODUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Floor Mounted Laboratory Fume Hoods.
2. Service fixtures (i.e., water, gas, etc.) and electrical service fittings in fume hoods.
3. Piping and wiring within service fittings, light fixtures, switches, and other electrical devices.
4. Filler panels and ceiling enclosures for fume hoods.

1.02 SCOPE AND CLASSIFICATION

A. This specification covers the requirements for the purchase of floor-mounted laboratory fume hoods for use with remote exhaust fan systems.

B. hood shall be equipped with bypass louvers located at the front upper section of the hood that open as the sash is closed, air sweeps under the sash from the 1” high opening over the floor.

C. Floor-mounted laboratory fume hood with a minimum interior width of 62.5 inches, and interior depth of 36” is required.

D. This specification sets the intent for quality, performance, and appearance.

E. Floor mounted hood shall be shipped knocked down with the proper assembly manual

1.03 PERFORMANCE REQUIREMENTS

A. General Design Requirements (See Part 2 for details)
1. Fume hoods shall function as ventilated, enclosed workspaces, designed to capture, contain, and exhaust fumes, vapors and particulate matter produced or generated within the enclosure.
2. Fume hood shall be factory designed to function as a bypass fume hood suitable for CAV mechanical systems.
3. Structure and Materials of construction
   a. Hoods are of double wall construction.
   b. Powder-coated, cold rolled steel exterior
   c. Galvanized steel support members
   d. Sheet molded composite panel internal liner.
4. Baffles
   a. Baffle slot pattern designed to optimize face velocity profile.
   b. Moving or adjustable baffles are not acceptable.
5. Sash
   a. Maximum vertical rising sash opening height is 63.6" (both sashes fully opened).
   b. Unobstructed viewing height is 78".
6. Access for maintenance is from both the front, interior, and exterior sides of the hood.
7. Services:

a. Hood manufacturer shall furnish and deliver all service outlets, accessory fittings, electrical receptacles, and switches, as listed in these specifications, equipment schedules or as shown on drawings.
b. Plumbing fittings mounted on the fume hood superstructures shall be pre-plumbed per section 2.03.
c. All electrical services are pre-wired to a single point internal junction box at the top right of the hood.

B. Containment
1. The purpose of this section is to set a standard of performance for the bidder's laboratory fume hood before award of contract and may not necessarily represent the operating conditions of the hoods after installation.
2. Evaluation of manufacturer's standard product shall take place in manufacturer's test facility meeting the following criteria.
   a. Lab to be located at manufacturer's place of business for the testing of hoods in accordance with modified ASHRAE Standard 110.
   b. All equipment must be properly calibrated.
   c. Qualified personnel familiar with the laboratory and its operation shall be available to perform the test.
3. Hood shall be tested to ASHRAE 110 modified test method as detailed below.
4. Fume hood upper sash shall be placed in the full-open position, lower sash in the closed position creating an opening of at least 25" between the two sashes, unless noted otherwise.
5. Ambient Temperature: 68 to 74 degrees F
6. Average Face Velocity: Face velocity average shall be 60 fpm, plus or minus 5%.
   a. Average face velocity must be achieved without exceeding the CFM noted in part C.
7. Tracer Gas Detection: Hood shall achieve a rating of 4.0AM0.00 maximum average and 4.0AM0.01 maximum spike (unless specifically otherwise noted).
   a. Detector probes shall be placed 3" in front of the sash plane. The test shall be conducted for each detector probe position and corresponding face velocity.
      1) Detector probe in the region of the nose and mouth of the mannequin. Test with average face velocity of 60 fpm.
   b. All data on the above, including instrumentation and equipment, and test conditions shall be provided on a report, including the average face velocities, and a separate graph-type performance curve on all tracer gas tests for all required fume hood widths.

C. Efficiencies
1. The fume hood shall maintain constant volumetric rate (+/- 5 CFM) and static pressure losses (+/- 0.01" H2O) across all sash positions.
2. The fume hood shall demonstrate a minimization of the volumetric rate of air (CFM) requirement at any given face velocity. Required CFM to achieve desired face velocity shall not exceed that which is noted in the chart below.
3. The fume hood shall demonstrate a minimization of static pressure loss (inches of H2O) at any given CFM. Static pressure loss at desired face velocity, and corresponding CFM, shall not exceed that which is noted in the chart below.

4.

Face Velocity (fpm) – top sash fully open (27.25 inches)	Airflow Volumetric Rate (CFM) @ Static Pressure (Inches of Water)
	6-foot hood
80	945, 0.29 in.
Face Velocity (fpm) – top sash 62.5% open (18inches)	Airflow Volumetric Rate (CFM) @ Static Pressure (Inches of Water)
	6-foot hood
80	625, 0.15 in. .
Notes: Bottom sash is closed for testing, and only open for loading. Top sash is fully open at 27.25 inches	

D. Noise Criterion: The hood shall have a Noise Criterion (NC) rating of less than 50; measured 36" in front of the hood with full open top sash, at 100 fpm face velocity.

E. Materials of Construction: Interior and Exterior materials of construction and finishes shall meet the requirements in Part 2 of this specification.

1.04 QUALITY ASSURANCE

A. Fume hoods shall be designed, including comprehensive engineering analysis, by a qualified, licensed Professional Engineer.

B. The laboratory hoods must conform to the following regulations and standards.
1. SEFA 1, Scientific Equipment and Furniture Association, Recommended Practices for Laboratory Fume Hoods
2. NFPA 45, National Fire Protection Association, Fire Protection for Laboratories Using Chemicals
3. ASTM E84-09C, ANSI 2.5, NFPA 255, UL 723, UBC 8-1 (42-1), Standard Test method for Surface Burning Characteristics of Building Materials
4. ASHRAE 110, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Method of Testing Performance of Laboratory Fume Hoods
5. ANSI/ASSP Z9.5, American Society of Safety Professionals, Laboratory Ventilation
6. OSHA, Federal Register 29 CFR Part 1910, Occupational Safety & Health Administration, U.S. Department of Labor, Occupational exposures to hazardous chemicals in laboratories.

C. Manufacturer's Qualifications
1. ISO 9001 Certified manufacturing plant and processes.
2. Ten installations of equal or larger size and requirements. Provide contact at each.
3. Only hood manufacturers who have had fume hoods as a principal product for 30 years are considered.

D. Fume hoods shall be **Made in America**
1. 95% or more of raw material and component suppliers shall be United States based.
2. Stainless and cold rolled steel used in manufacturing shall be sourced from United States steel mills.

3. Final product must be fabricated and assembled within the United States of America.
4. Owner reserves the right to evaluate Made in America claims for compliance with the Bureau of Consumer Protection.

E. Supply all equipment in accordance with this specification. Offering a product differing in materials, construction, or performance from this specification requires written approval obtained seven days or more before the proposal deadline.

F. The owner/architect reserves the right to reject qualified or alternate proposals and to award based on product value where such action assures the owner greater integrity of product.

G. Manufacturer's warranty against defects in material or workmanship on its fume hoods will be for 1 year from date of installation or 2 years from date of purchase, whichever is sooner, and includes replacement of parts (except lamps) and labor.

1.05 SUBMITTALS

A. Action Submittals
1. Laboratory hood specification sheets and product manuals shall be submitted by the hood manufacturer upon request and include safe and proper operation and maintenance information.
2. Shop Drawings: Include plans, elevations, sections, and details.
   a. Indicate details for anchoring fume hoods to permanent building construction including locations of blocking and other supports.
   b. Indicate locations and types of service fittings together with associated service supply connection required.
   c. Indicate duct connections, electrical connections, and locations of access panels.
   d. Include roughing-in information for mechanical, plumbing, and electrical connections.
   e. Provide face opening, volumetric rates, and static pressure drop data.
3. Submit a document detailing the information supplied on the Hood Safety Practices Label to verify compliance to specifications.

B. Informational Submittals
1. Product Test Reports: Showing compliance with specified performance requirements.
2. Independent validation:
   a. Written verification that the laboratory fume hoods carry the ETL listed mark for the following.
      1) UL 61010-1, Underwriters Laboratories Inc., Electrical Equipment for Laboratory Use
      2) CAN/CSA C22.2 No. 61010-1, Canadian Standards Association, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use
      3) UL 1805, Underwriters Laboratories Inc., Standard for Laboratory Hoods, and Cabinets
   b. Written verification that 230-volt model fume hoods carry the CE conformity marking as required by the Council of European Communities.
   c. Written verification from an outside testing agency confirming coating compliance to SEFA 8, Recommended Practices for Laboratory Grade Metal Casework, 8.0 Cabinet Surface Finish Tests

3. Documentation of ISO 9001 Certified manufacturing plant and processes.
4. List of five installations (of equal or larger size and requirements) is available upon request. Provide contact at each.
5. Declaration of Made in America. Owner reserves the right to evaluate Made in America claims for compliance with the Bureau of Consumer Protection.

C. Material Submittals
1. Samples for Verification: of the hood exterior wall material, interior liner and baffle material, epoxy work surface material, and color selection chips are available from the hood manufacturer upon request.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or another suitable material.

B. Schedule delivery of equipment so that spaces are sufficiently complete that equipment can be installed immediately following delivery.

1.07 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install fume hoods until building is enclosed, wet work and utility roughing-in are complete, and HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers: Bedcolab, Labconco or equal

2.02 HOOD CONSTRUCTION

A. Materials

1. Commercial quality cold rolled steel sheets as per ASTM A366-85, class 1
2. Stainless steel sheets, type 316 with # 4 satin finish, per ASTM A240, A480, A666, A262
3. Polished laminated glass as per CAN/CGSB.12.1, first quality, 6 mm (1/4") total thickness
4. High Density Polyethylene (HDPE) liner, CAS no. 9002-88-4
5. Fiber reinforced thermoset polyester (FRP) plastic with smooth white chemical resistant finish.

B. General

1. These hoods are equipped with an air deflector system that controls the incoming air velocity thus providing a constant air exhaust volume.
2. These hoods are equipped with bypass louvers located at the front upper section of the hood that open as the sash is closed, air sweeps under the sash from the 1" high opening over the floor.
3. The sash opening is beveled in order to reduce dead air pockets and air turbulence.

C. Hood Construction

1. The hood structure shall be a double wall construction with steel exterior panels painted with the same process as the furniture and a choice of interior finish as described under section 11.H. All steel structural channels, support and remote-control faucet mechanisms are installed within the wall structure.
2. All steel used in the fabrication of the exterior panels is of premium quality and is finished as described in the furniture section.
3. All screws used to fix the exterior structural channels are zinc-plated steel and all interior liner hardware are made of chemical resistant black nylon. Keeps sash on track and provides a fingertip control of the sash height. The sash panels are made of ¼" safety laminated glass.
4. The hood structure must be self-supporting, forming a complete rigid structure to support the inside lining, allowing the replacement of interior lining panels without the need to remove the hood from its installed location.
5. The hoods shall be designed with the following minimum inside dimensions to maximize the working surface: 25½" working floor surface depth between the baffles and the sash interior; 84¼" clear height between the working floor surface and the inside top of the hood.

Wall thickness should not exceed 4 ¾" to provide a maximum inner working area. Interior liner: High Density Polyethylene white resin panels (HDPE) ¼" with white smooth chemical resistant finish are supplied with chemical resistant nylon rivets.

6. Vertical sashes shall be designed to provide an opening height of the top panel of 27¼". The front configuration shall be designed to provide a 76" height clear view of the inside of the hood. Provide chain and sprocket sash system.

7. The fume hood shall be equipped with a fluorescent light fixture, a light switch and two duplex 120 V/20A electrical outlets on the front posts. All electrical components shall be pre-wired to a junction box located on top of the hood and are CSA-US/UL approved.

8. The fluorescent light fixture, including two tubes sized based on the size of the hood, shall be installed on the exterior top side of the hood and isolated from the hood's interior by a ¼" (laminated safety glass to protect the lamps from vapors or fumes inside the hood. The chosen lamp must supply a minimum of 80 feet candle measured at the working surface.

D. Exterior Hood Panels Finishing

1. When fabrication of the unit is completed, all surfaces shall be free of scratches and imperfections. Welds will be ground smooth where necessary. The unit will be washed using a three-stage iron phosphate process for proper surface preparation and subsequently, dried in a dry off oven to remove all humidity traces.

2. 2. A high quality chemical resistant polyurethane paint will then be applied to all surfaces including the interior of door and drawer panels using an electrostatic spray process. The parts will be oven baked for the duration and temperature recommended by the paint manufacturer. Painted surfaces shall conform to A.A.M.A. 2603.

3. Color: To be selected by architect

E. Fume Hood Accessories

1. Service Fittings:

   a. All service fittings are remotely controlled and shall be front loaded needle valves for:

      1) Nitrogen

      2) Helium

2.03 CASEWORK

A. (1) - 4' wide inset steel sink base cabinet.

B. (1) - 3’ wide modesty panel with table rails and end panel.

C. (1) chemical resistant plastic laminate countertop.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fume hoods.
B. Coordinate with other trades for the proper and correct installation of plumbing and electrical rough-in and for rough opening dimensions required for the installation of the hood.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General: Install fume hoods according to shop drawings and manufacturer's written instructions.
B. Install level, plumb, and true; shim as required, using concealed shims, and securely anchor to building and adjacent laboratory casework.
C. Securely attach access panels but provide for easy removal and secure reattachment. Where fume hoods abut other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.
D. Neighboring splash blocks shall not be attached directly to the hood.
E. Install according to standards required by authority having jurisdiction.
F. Sequence installations to ensure utility connections are achieved in an orderly and expeditious manner.
G. Touch up minor damaged surfaces caused by installation. Replace damaged components as directed by Architect.

3.03 FIELD QUALITY CONTROL

A. NFPA 45 and ANSI/ASSP Z9.5 require that fume hoods be field tested when installed.
B. Field test installed fume hoods according to modified ASHRAE 110 to verify compliance with performance requirements.
    1. Adjust fume hoods, hood exhaust fans, building's HVAC system, and make other corrections until tested hoods perform as specified in fume hood schedule.
    2. After making corrections, retest fume hoods that failed to perform as specified.

3.04 ADJUSTING AND CLEANING

A. Adjust moving parts for smooth, near silent, accurate sash operation with one hand. Adjust sashes for uniform contact of rubber bumpers. Verify that counterbalances operate without interference.
B. Clean finished surfaces, including both sides of glass; touch up as required; and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.
C. Clean adjacent construction and surfaces that may have been soiled during installation of work in this section.
D. Provide all necessary protective measures to prevent exposure of equipment and surfaces from exposure to other construction activity.
E. Advise contractor of procedures and precautions for protection of material and installed equipment and casework from damage by work of other trades.

SECTION 230553 - IDENTIFICATION FOR HVAC AND LAB EQUIPMENT

PART 1 - GENERAL

1.1 BUY AMERICAN ACT REQUIREMENTS

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND WARNING LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White.
4. Minimum Letter Size: 1/2 inch.
5. Fasteners: Stainless-steel self-tapping screws.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Fume Hood Panic Hardware and Notification Devices:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: Yellow.
4. Minimum Letter Size: 1/2 inch.
5. Fasteners: Metallic Wall Anchors.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Equipment and Warning Label Content: Include equipment's designation or unique equipment number.

~~B.~~D. Fume Hood Panic Hardware and Notification Devices Label Content: Include equipment's designation or unique equipment number, lab identification number and room number.

~~C.~~E. ~~Refer to Spec section 283113 FIRE ALARM SYSTEM for fume hood labeling requirements~~Refer to NIST equipment labeling naming requirements in NIST Site Standards and General requirements document for equipment naming conventions. NIST Site Standards are included in the 01D B2 1330 Fume Hood Replacement Project Specifications. All labeling shall be approved by NIST Fire Protection Authority Division (FPAD)

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 FUME HOOD PANIC HARDWARE AND NOTIFICATION DEVICE LABEL INSTALLATION

A. Install or permanently fasten labels adjacent to hardware or device.

B. Locate equipment labels where accessible and visible.

~~B.~~C. END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.2 INFORMATIONAL SUBMITTALS

A. Certified TAB reports.

1.3 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.4 FIELD CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PROCEDURES FOR LAB FUME HOODS

A. Fume hood shall be tested in accordance with ANSI/ASHRAE 110-2016

3.2 FINAL REPORT

A. General: Prepare a certified written report.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Field test reports prepared by system and equipment installers.
2. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Contractor's name and address.
6. Report date.
7. Signature of TAB supervisor who certifies the report.
8. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
9. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

10. Nomenclature sheets for each item of equipment.
11. Data for terminal units, including manufacturer's name, type, size, and fittings.
12. Notes to explain why certain final data in the body of reports vary from indicated values.

D. Final report shall be reviewed and approved by NIST BSHED

END OF SECTION 230593

SECTION 233113 – PVC LABORATORY EXHAUST DUCTWORK

PART 1 - GENERAL

1.1 PERFORMANCE REQUIREMENTS

A. Corrosion resistant PVC duct, for use at temperatures up to and including 140°F.

1.2 ACTION SUBMITTALS

A. Shop Drawings:
   1. Factory- and shop-fabricated ducts and fittings.
   2. Joint construction.
   3. Equipment installation based on equipment being used on Project.

PART 2 - PRODUCTS

2.1 PVC ROUND DUCTS AND FITTINGS

A. PVC material compounds used in the manufacture of HARRISON SUPERDUCT® PVC pipe and the fabrication of HARRISON SUPERDUCT® fittings shall conform to Type 1 Grade 1 PVC, Cell Class 12454B, as described in ASTM D-1784.

B. Duct diameters thru 20" & 24" will be extruded and of seamless construction. Sizes thru 18" will have a 0.187" wall thickness. 20" diameter will be @ 0.219" and 24" @ 0.250" thickness.

C. Fabricated (heat formed) duct diameters 22" and 26" thru 30" will have a 0.187" wall while 32", 34" and 36" & larger diameters will have a 0.250" wall. Fabricated duct shall consist of a singular buttwelded seam, thermally fused under computer controlled temperature and pressure, without the use of PVC welding/filler rod.

D. All extruded duct shall be furnished in 10 or 20 foot lengths, plain end; fabricated duct will be furnished in standard 4 foot lengths with a coupling attached on one end.

E. Three piece 90° elbows and two piece 45° elbows are considered standard and are furnished with a centerline radius of approximately 1 to 1 1/2 times the duct diameter. Five piece 90° elbows and 3 piece 45° elbows, per SMACNA specifications, can be provided, on specific project requirements.

F. All couplings will be "sleeve" type style having an over-all length of 4 1/2"

G. All belled end sockets (5" and above) shall have a minimum socket depth of 2" or more. 2", 3", & 4" belled socket depths will be @ 1 3/4".

H. Branch fittings are designed to enter the main duct, at an angle not exceeding 45° Branch 90° tees are available where systems allow.

I. Transition fittings shall have formed corners where practical. They will be of concentric design (unless otherwise requested) with a tapered cone-type body.

J. Reducer couplings having a size reduction greater than "two-step", shall be formed with cone-type body having an overall length generally calculated @ 4" per 1" size reduction, where space allows. One-step and two-step reducers will have a smooth-flow concentric design.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Install PVC ductwork per manufacturer’s directions

3.2 DUCT SCHEDULE

A. Field verify existing ductwork schedule

END OF SECTION 233113

SECTION 233416 – UTILITY SET FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. fan performance curves with system operating conditions indicated.
3. fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.
3. Fan shall be manufactured at an ISO 9001 certified facility.

2.2 DIRECT DRIVE CENTRIFUGAL FANS

A. Acceptable Manufacturers:

1. Greenheck model FJ or equal by:
   a. Loren Cook
   b. Twin City fans

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, direct drive centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. General
1. Base fan performance at standard conditions (density 0.075 Lb/ft3).
2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be belt in AMCA arrangement 10 according to drawings.
4. Fans are equipped with lifting lugs.
5. When properly anchored to the roof structure, the standard fan / stack assembly shall withstand wind loads of up the equivalent load of 115 mph windspeed, without the need for guy wires or additional structural support.
6.
7.

D. FAN HOUSING AND INTEGRAL STACK
1. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
2. Fan shall be of airtight construction with the scroll panel material formed and embedded into the side panels continuously welded heavy gauge scroll construction.
3. Housing shall include discharge stack of the same material as fan housing to increase the overall discharge height of the unit. Minimum overall unit height with stack to be 10 feet from the roof deck.
4. Discharge stack shall be provided with tie down points for guywires.
5. Stack material to be a minimum of 18 gauge. Stack to match outlet dimensions of the fan.
6. Fan shall be horizontal connection.
7.

E. Fan Wheel:
1. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel hub shall be keyed and securely attached to the fan shaft. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency

F. Coating:
   1. Fan shall be coated with the Greenheck Hi-Pro Polyester or equivalent.

G. Accessories:
   1. Provide NEMA 3R electrical disconnect factory wired.
   2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
   3. Fan access door
   4. Equipment supports
   5. Restrained spring isolators

2.3 MOTORS

A. EC Motors shall be open type enclosure and electronic commutation type motor (ECM) specifically designed for fan applications. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by a potentiometer dial mounted at the motor Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - . EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

E. Unit Support: Install centrifugal fans level on structural equipment support.

F. Install units with clearances for service and maintenance.

3.2 CONNECTIONS

A. Install ducts adjacent to fans to allow service and maintenance.

3.3 DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

SECTION 260010

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL REQUIREMENTS

1.1 DESCRIPTION OF THE WORK

A. This Division requires providing complete functioning systems, and each element thereof, as specified, indicated, or reasonably inferred, on the Drawings and in these Specifications, including every article, device, or accessory (whether or not specifically called for by item) reasonably necessary for each system's functioning as indicated by the design and the equipment specified.

B. Division 26 of these Specifications and Drawings numbered with prefixes E, SE, ME and MEP, generally describe these systems, but the scope of the electrical Work includes all such Work indicated in all Contract Documents: Division 0 and 1 specifications, Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.

1.2 QUALITY ASSURANCE

A. Execute all Work under this Division in a thorough and professional manner by competent and experienced workers duly trained to perform the Work.

B. Install all Work in strict conformance with all manufacturers' requirements and recommendations unless these Documents exceed those requirements. Install all equipment and materials in a neat and professional manner, aligned, leveled, and adjusted for satisfactory operation, in accordance with NECA guidelines.

C. All material and equipment shall be new, of the best quality and design, free from defects and imperfections and with markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Provide all material and equipment of the same type from the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items of the same types specified within this Division shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this Project.

1.3 CODES, REFERENCES AND STANDARDS

A. Execute all Work in accordance with, and comply at a minimum with, National Fire Protection Association (NFPA), NIST general contract requirements, General instructions for conducting work at NIST Boulder Campus, NIST site standards/naming conventions and all national, state and local building codes, ordinances and regulations in force governing the Work.

B. The governing codes are minimum requirements. Where the Drawings and Specifications exceed the code requirements the Drawings and Specifications shall prevail.

C. BUY AMERICAN ACT REQUIREMENTS:

1. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

D. All material, manufacturing methods, handling, dimensions, installations and test procedures shall conform to but not be limited to the following industry standards, acts and codes:

1. IBC International Building Code
2. ADA Americans with Disabilities Act
3. AIA Guidelines for Design and Construction of Hospital and Healthcare
4. Facilities or State Adopted Regulations
5. AEIC Association of Edison Illuminating Companies
6. ANSI American National Standards Institute
7. ASTM American Society of Testing Materials
8. AWS American Welding Society
9. AWWA American Water Works Association
10. ETL Electrical Testing Laboratories
11. ICEA Insulated Conductors Engineers Association
12. IEEE Institute of Electrical and Electronics Engineers
13. IES Illuminating Engineering Society
14. NBFU National Board of Fire Underwriters
15. NEC National Electrical Code, NFPA 70
16. NECA National Electrical Contractors Association
17. NEMA National Electrical Manufactures' Association
18. NETA InterNational Electrical Testing Association
19. NFPA National Fire Protection Association
20. NIST National Institute of standards and Technology
21. OFPM Office of Facilities and Property Management

22. OSHA Occupational Safety and Health Act

23. UL Underwriter's Laboratories

1.4 DEFINITIONS

A. Whenever used in these Specifications or Drawings, the following terms shall have the indicated meanings:

1. Furnish: "Supply and deliver to the project site, ready for unloading, unpacking, assembling, installing, and similar operations."

2. Install: "Perform all operations at the project site, including, but not limited to, and as required: unloading, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, testing, commissioning, starting up and similar operations, complete, and ready for the intended use."

3. Provide: "Furnish and install complete and ready for the intended use."

4. Furnished by User, Furnished by NIST, or Furnished by Others: "An item furnished by the User, by NIST or under other Divisions or Contracts, and installed under the requirements of this Division, complete, and ready for the intended use, including all items and services incidental to the Work necessary for proper installation and operation."

5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division, and is a Consultant to, and an authorized representative of, the Construction Manager, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Construction Manager."

6. AHJ: Any regulatory and/or inspection agency (Authority) Having Jurisdiction over the Work.

7. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other NRTLs that are acceptable to the AHJ, and standards that meet the specified criteria.

1.5 COORDINATION

A. The Contractor shall review and shall coordinate with other Divisions for electrical work included in other Divisions but not listed in Division 26 or indicated on electrical Drawings.

B. The Contractor shall visit the site and ascertain the conditions to be encountered in installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make do provisions for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, and incorrect or faulty

installation of any of the Work under this Division or for additional compensation for any Work covered by this Division.

C. The Contractor shall refer to Drawings and Divisions of the other trades and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. Make all offsets required to clear equipment, beams and other structural members, and to facilitate concealing conduit in the manner anticipated in the design.

D. The Contractor shall provide materials with trim that will fit properly for the types of ceiling, wall, or floor finishes installed.

E. The Contractor shall maintain an electrical foreman on the jobsite at all times to coordinate this Work with other trades so that various components of the electrical systems is installed at the proper time, fits the available space, and allows proper service access to all equipment. Carry on the Work in such a manner that the Work of the other trades will not be handicapped, hindered, or delayed at any time.

F. Work of this Division shall progress according to the "Construction Schedule" as established by the Prime Contractor and as approved by NIST/OFPM Personnel. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule to ensure successful achievement of all schedule dates.

1.6 MEASUREMENTS AND LAYOUTS

A. Verify all existing and all final locations of equipment, rough-ins and other components with field measurement. Calculated dimensions or dimensions indicated in the Contract Documents take precedence to scaled dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing all Contract Documents. The Contractor shall be held responsible for errors that could have been avoided by proper checking and inspection.

1.7 SUBMITTALS

A. Refer to Division 1 and the Contract Documents for submittal requirements.

1.8 ELECTRONIC DRAWING FILES

A. In electronic drawing files, as-built conditions in PDF and AutoCAD form shall be provided to NIST/OFPM personnel at project conclusion.

1.9 SPARE PARTS

A. Provide to the facilities/building managers the spare parts specified in the individual specification sections.

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment and material to the job site in their original containers with labels intact, fully identified with manufacturer's name, make, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.

B. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and always take every precaution to properly protect equipment and material from damage, including the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which becomes rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to NIST/OFPM.

C. Contractor shall be responsible for the safe storage of Contractor's own tools, material and equipment.

1.11 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1. In addition to the requirements in Division 1, the following requirements apply:

B. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

C. Perform cutting, fitting, and patching of mechanical and plumbing equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work.

2. Remove and replace defective Work.

3. Remove and replace Work not conforming to the requirements of the Contract Documents.

4. Remove samples of installed Work as specified for testing.

5. Install equipment and materials in existing structures.

D. Cut, remove and legally dispose of selected equipment, components, and materials as indicated, including but not limited to removal of conduit, wiring, panel boards, light fixtures and trim, and other electrical items made obsolete by the new Work.

E. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

F. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

G. Patch finish surfaces and building components using new materials matching the original installation and experienced installers.

1.12 RECORD DOCUMENTS

A. Prepare record documents in accordance with requirements in Division 1. In addition to the requirements specified in Division 1, indicate the following installed conditions created in AutoCAD on solid state flash drive:

1. Major raceway systems, size and location for both exterior and interior.

2. Approved substitutions, contract modifications and actual equipment materials installed.

3. Indicate all deviations from original Contract Documents.

1.13 OPERATION AND MAINTENANCE MANUALS

A. Operation and Maintenance manuals shall include product data and required shop drawings worked to reflect "as-built" conditions. In addition to the requirements specified in Division 1, including the following information for all equipment:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating instructions to include start up, break-in and routine and normal operating instruction, regulation, control, stopping, shutdown, emergency instruction and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting, disassembly, repair, reassembly, aligning and adjusting instructions.

4. Servicing instructions, lubrication charts and schedules and parts listed.

1.14 PROJECT MANUAL

A. Assemble and submit at completion of the project per the requirements of Division 1, a project manual that includes at a minimum the following:

1. All RFI's with Engineer's responses.

2. Copies of all approved submittals, including all shop drawings.

3. Copies of all test reports.

4. Copies of all reports by inspectors representing authorities having jurisdiction. Include initial and final reports and any Contractor responses to same.

1.15 HAZARDOUS MATERIALS

A. The Contractor is hereby advised that building components to be encountered as part of the Work may have been painted or stained with lead based products. It is the Contractor's responsibility to take all proper precautions concerning potential lead based products and to comply with the Occupational Safety and Health Administration's Lead in Construction Rule, 29 CFR Part 1926 et al, and Hazard Communication Standard 29 CFR 1926.59. These precautions include material sampling and analysis, OSHA required worker protection, area isolation, engineering and work practice controls, and cleaning. The Contractor shall handle all suspect or identified lead based products with care as not to scratch, scrape, grind, or in any other way release the lead based products, except as specifically required by the Work. The Contractor is responsible for properly

cleaning all areas where suspect or identified lead based paint products are disturbed prior to returning the building to NIST/OFPM.

B. The Contractor shall not install new lead or lead bearing products as defined by the U.S. Consumer Product Safety Commission's Ban of Lead-Containing Paint and Certain Consumer Products Bearing Lead-Containing Paint 16 CFR 1303 et al., which is 0.6% lead and greater by weight of the total nonvolatile content of the paint or of the dried paint film, including but not limited to paints, coatings, stains, etc.

C. If asbestos or any other hazardous material is or will be encountered while performing the Work, the Contractor shall immediately cease work and notify NIST/OFPM.

1.16 EXISTING CONDITIONS

A. Existing conditions indicated on the Drawings are taken from the best information available to the Engineer, existing drawings, and from limited, in-situ, visual site observations; and they are not to be construed as "AS BUILT" conditions. The information is shown to help establish the extent of the Work.

B. Verify all actual existing conditions at the project site and perform the Work as required to meet the existing conditions and the intent of the Work.

1.17 ACCESS TO EQUIPMENT

A. Locate all pull boxes, junction boxes and controls to provide easy access for operation, service inspection and maintenance. Provide an access door where equipment or devices are located above or behind inaccessible walls and ceilings.

B. Maintain all code required clearances and clearances required by manufacturers.

1.18 ELECTRICAL INSTALLATIONS

A. Sequence, coordinate and integrate the various elements of electrical systems, materials and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment and materials installation with installation of other building components (structural, mechanical, etc.).

2. Coordinate the installation of required boxes, supporting devices and steel pipe sleeves to be set in poured-in-place concrete and other construction components, as they are constructed.

3. All openings in or through floor construction, fire walls or smoke partitions shall be sealed. Fire stopping, sealing materials and installation methods shall be UL classified systems.

4. Sequence, coordinate and integrate installation of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

5. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible.

6. Install systems, materials and equipment to conform with approved submittal data to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Construction Manager.

7. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components.

8. Install electrical equipment to facilitate servicing, maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

9. Install systems, materials and equipment giving right-of-way priority to systems required to be installed at a specific slope.

10. Tighten electrical connections and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirement are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

11. Install electrical equipment in accordance with manufacturer's written instructions, applicable requirements of NECA's "Standard of Installation" and in accordance with recognized industry practices to fulfill project requirements.

12. Immediately prior to final inspection, the Electrical Contractor shall clean all material and equipment installed under the Electrical Contract. Dirt, dust, plaster, stains and foreign matter shall be removed from all interior and exterior surfaces.

13. Adjust operating mechanisms for free mechanical movement.

14. Where types, sizes or ratings of any electrical equipment, materials or accessories are not indicated, comply with established industry standards for those applications indicated.

15. Where applicable and otherwise noted, provide NEMA Type 1 general-purpose enclosures for equipment in interior applications and NEMA Type 3R weather tight enclosures for equipment in exterior applications and any interior applications susceptible to moisture.

16. Concrete pads shall be provided for all floor mounted electrical equipment. Equipment pads shall be 4" thick as shown on the drawings, or where not shown shall generally conform to the shape of the piece of equipment it serves with a minimum 3" margin around the equipment and supports. Pads shall be a minimum 3-1/2" high and made of a minimum 28 day, 3000 psi concrete reinforced with 6"x6" welded wire mesh. Tops and sides of pad shall be troweled to a smooth finish, equal to that of the floor with all exterior corners bull nosed to a 3" radius.

17. Furnish and install galvanized anchor bolts for all equipment placed on concrete pads or slabs. Bolts shall be the size and number recommended by the manufacturer of the equipment and shall be located by means of suitable templates.

1.19 PAINTING

A. Paint electrical equipment, products and material as indicated on the drawings or specified elsewhere using products and methods specified elsewhere.

B. Re-finish all field-threaded ends of galvanized conduits and field-cut ends of galvanized supports with a cold-galvanizing compound approved for use on conductive surfaces. Follow closely manufacturer's instructions for pre-cleaning surfaces and application.

C. Factory finishes, shop priming and special finishes are specified in the individual equipment Specification sections.

D. Where factory finishes are provided, and no additional field painting is specified, touch up or refinish, marred or damaged surfaces to leave a smooth, uniform finish.

1.20 ADJUSTING, ALIGNING AND TESTING

A. Adjust, align and test all electrical equipment furnished and/or installed under this Division.

B. Check motors for alignment with drive and proper rotation and adjust as required.

C. Check and test protective devices for specified and required application and adjust as required.

D. Check, test and adjust adjustable parts of all light fixtures and electrical equipment as required to produce the intended performance.

E. Verify that completed wiring system is free from short circuits, unintentional grounds, low insulation impedances, and unintentional open circuits.

F. After completion, perform tests for continuity, unwanted grounds, and insulation resistance in accordance with the requirements of NFPA 70 and NETA.

G. Infrared Scanning: Within 60 days of substantial completion, perform an infrared scan of each termination and splice for conductors #3 AWG and larger. Provide scan reports to owner.

H. Be responsible for the operation, service and maintenance of all new electrical equipment during construction and prior to acceptance by NIST/OFPM of the complete project under this Contract. Maintain all electrical equipment in the best operating condition including proper lubrication.

I. Notify NIST and OFPM immediately of all operational failures caused by defective material, labor or both.

J. Refer to individual Sections for additional and specific requirements.

1.21 START-UP OF SYSTEMS

A. Contractor shall provide all labor, material and equipment necessary to perform the specified electrical systems start-up, testing and adjusting.

B. Where start-up, testing and adjusting of both electrical and mechanical systems is specified to be provided by or witnessed by others (including governing authorities), Contractor shall provide all labor, materials and equipment required to witness, support and generally facilitate the work being performed by others.

C. Prior to start-up of electrical systems, check all components and devices, lubricate items appropriately, and tighten all screwed and bolted connections to manufacturers' recommended torque values using appropriate torque tools.

D. Each power, lighting and control circuit shall be energized, tested and proved free of breaks, short-circuits and unwanted grounds.

E. Adjust taps on each transformer for rated secondary voltages.

F. After all systems have been inspected and adjusted, confirm all operating features required by the Drawings and Specifications and make final adjustments as necessary.

G. Demonstrate that all equipment and systems perform properly as designed per Drawings and Specifications.

H. At the time of final review and tests of the power and lighting systems, all equipment and system components shall be in place and all connections at panelboards, switches, circuit breakers, and the like, shall be complete. All fuses shall be in place, and all circuits shall be continuous from point of service connections to all electrical devices.

1.22 TESTS

A. Perform tests where required by these Specifications. The tests shall establish the adequacy, quality, safety, and reliability for each electrical system installed.

B. For specific testing requirements of each electrical systems, refer to the Specification section that describes that system.

C. Promptly correct all failures or deficiencies revealed by these tests as determined by the Engineer.

END OF SECTION 260010

SECTION 260500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes limited scope general construction materials and methods, electrical equipment coordination, and common electrical installation requirements as follows:

1. Joint sealers for sealing around electrical materials and equipment, and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.

2. Through-penetration firestop systems for electrical equipment and penetrations through the fire-resistance rated assemblies, including both blank openings and openings containing penetrating items such as conduits, cabling, cable trays and bus duct.

1.2 BUY AMERICAN ACT REQUIREMENTS

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.3 SUBMITTALS

A. Product data for the following products:

1. Through-penetration firestop systems.

1.4 QUALITY ASSURANCE

A. Provide through-penetration firestop systems that comply with the following requirements.

1. Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL, or another agency performing testing and follow-up inspection services for firestop systems acceptable to authorities having jurisdiction.

2. Through-penetration firestop system products bear classification marking of qualified testing and inspection agency.

B. Engage an experienced installer who is certified, licensed or otherwise qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products per specified requirements. A manufacturer's willingness to sell its through-penetration firestop system products to Contractor or to an installer engaged by Contractor does not in itself confer qualifications on buyer.

1.5 PROJECT CONDITIONS

A. Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limitations recommended by manufacturer.

B. Do not install through-penetration firestop systems when substrates are wet.

PART 2 - PRODUCTS AND MATERIALS

2.1 FIRESTOPPING

A. Firestopping sealants, systems and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E 814, by Underwriters' Laboratories, Inc., or other NRTL acceptable to AHJ.

B. General

1. Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

2. Provide components for each through-penetration firestop system that are needed to install fill materials. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

3. Use only through-penetration firestop system products that have been tested for specific fire-resistance-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

C. Performance Requirements

1. Provide products that upon curing, do not re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during and after construction.

2. Openings within walls and floors designed to accommodate cabling systems subjected to frequent cable changes shall be provided with re-enterable products specifically designed for retrofit.

D. Latex Sealants: Single component latex formulations that upon cure do not re-emulsify during exposure to moisture.

E. Firestop Devices: Factory-assembled steel collars lined with intumescent material sized to fit specific outside diameter of penetrating item.

F. Firestop Putty: Intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers or silicone compounds.

G. Firestop Putty Pads: Intumescent, non-hardening putty pads to be installed on metallic and nonmetallic electrical switch and receptacle boxes to reduce horizontal separation between boxes to less than 24”.

H. Wrap Strips: Single component intumescent elastomeric strips faced on both sides with a plastic film.

I. Firestop Pillows: Re-enterable, non-curing, mineral fiber core encapsulated with an intumescent coating contained in a flame retardant poly bag.

J. Mortar: Portland cement based dry-mix product formulated for mixing with water at Project site to form a non-shrinking, water-resistant, homogenous mortar.

K. Silicone Sealants: Moisture curing, single component, silicone elastomeric sealant for horizontal surfaces (pourable or nonsag) or vertical surface (nonsag).

L. Silicone Foam: Multicomponent, silicone-based liquid elastomers, that when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

M. Composite Sheet: Intumescent material sandwiched between a galvanized steel sheet and steel wire mesh protected with aluminum foil.

N. Cast-In-Place Firestop Device: Single component molded firestop device installed on forms prior to concrete placement with totally encapsulated, tamper-proof integral firestop system and smoke sealing gasket.

O. Firestop Plugs: Re-enterable, foam rubber plug impregnated with intumescent material for use in blank openings and cable sleeves.

P. Fire-Rated T Rating Collar Device: Louvered steel collar system with synthetic aluminized polymer coolant wrap installed on metallic pipes where T Ratings are required by applicable building code requirements.

Q. Fire-Rated Cable Grommet: Molded two-piece grommet made from plenum grade polymer with a foam inner core for sealing individual cable penetrations up to 0.27 in. (7 mm) diameter.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Coordinate seals with wall, ceiling, roof or floor materials and rating of the surface (sound, fire, waterproofing, etc.)

C. Comply with NECA 1.

D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

F. Right of Way: Yield to raceways and piping systems installed at a required slope.

3.2 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire/smoke-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

B. Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellents, and any other substances that may inhibit optimum adhesion.

C. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.3 THROUGH-PENETRATION FIRESTOP SYSTEM

A. General Requirements: Install through-penetration firestop systems in accordance with the conditions of testing and classification as specified in the published design.

B. Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration firestop systems products.

C. Seal all openings or voids made by penetrations to ensure an air and water-resistant seal.

D. Protect materials from damage on surfaces subjected to traffic.

3.4 JOINT SEALERS

A. Preparation for Joint Sealers

1. Clean surfaces of penetrations, sleeves, or both, immediately before applying joint sealers, to comply with recommendations of joint sealer manufacturer.

2. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

B. Application of Joint Sealers

1. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

2. Tooling: Immediately after sealant application and prior to time shining or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

END OF SECTION 260500

SECTION 260502

EQUIPMENT WIRING SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes limited scope for electrical connections to equipment specified under other sections or divisions, or furnished under separate contracts or by the Owner.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Unless otherwise noted, perform all electrical work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this contract.

B. Coordinate with work described in Division 23 specifications.

C. Obtain and review shop drawings, product data, and manufacturer's instructions for equipment furnished under other sections.

D. Determine connection locations and rough-in requirements based on shop drawings.

E. Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.

F. Sequence electrical connections to coordinate with start-up schedule for equipment.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section “General Electrical Requirements”.

B. Product data for the following products for:

1. Special connectors

2. Special conductors or cable assemblies.

C. Shop drawings for:

1. Detailing electrical characteristics, wiring diagrams, fabrication and installation for wiring systems.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Authorities Having Jurisdiction.

2. Marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.1 CORDS AND CAPS

A. Attachment Plugs: Conform to NEMA WD 1.

B. Configuration: NEMA WD 6, matching receptacle configuration at outlet provided for equipment, or as required by the equipment manufacturer.

C. Cord: See Paragraph “Flexible Cords” in Division 26 Section “Low-voltage Electrical Power Conductors and Cables”.

D. Provide cord size suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

3.2 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

B. Provide fire-resistive protective assembly or an electrical circuit protective system for feeders and control circuit conductors and cables having a fire-resistance rating of not less than 2 hours where required by NFPA or local building codes. Types of systems requiring a fire-resistive protective assembly include, but are not limited to:

1. Feeders for Emergency Power systems
2. Smokeproof Enclosure Pressurization systems
3. Smoke Removal systems
4. Fire service and Occupant Evacuation Elevator systems

3.3 ELECTRICAL DEVICES

A. Install disconnect switches, controllers, control stations, and control devices (other than temperature control devices) as indicated, specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.

3.4 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturers' instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquid tight flexible conduit with watertight connectors in damp or wet locations.

C. Make wiring connections using conductors and cable with insulation suitable for temperatures encountered in heat producing equipment.

D. Provide receptacle outlet where connection with attachment plug is indicated. Provide cord and cap where field-supplied attachment plug is indicated on the Drawings.

E. Provide suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

F. Provide interconnecting conduit and wiring between devices and equipment where indicated on the Drawings.

3.5 EQUIPMENT

A. When equipment is delivered in separate parts and field assembled, internal wiring, indicated on Shop Drawings as field wiring, will be provided by the equipment supplier, unless otherwise noted.

B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.

C. Provide all control and interlock wiring for all equipment that is not included within the responsibility of Division 22 or 23.

D. Motorized Damper: Provide lockable toggle, pilot lighted disconnect switch in an accessible location at each motor actuator, or group of motor actuators.

3.6 food service (servery) equipment

A. Provide power connection to all equipment as indicated or as otherwise required to accommodate the equipment indicated in the food service equipment drawings and specifications.

B. Coordinate and provide the appropriate receptacle for equipment being installed as required for proper operation. Coordinate the required quantity of conductors prior to pulling wire to outlet box.

C. Provide a local recessed non-fused equipment disconnect for kitchen equipment as required by the applicable codes and jurisdictions. Coordinate exact location prior to rough-in and maintain all code required clearances.

D. Provide control wiring and conduit for all equipment that is not indicated as being within the responsibility of the equipment manufacturer or installer.

E. When equipment is delivered in separate parts and field assembled, internal wiring, indicated on Shop Drawings as field wiring, shall be provided by the equipment installer, unless otherwise noted.

F. Coolers and Freezers: Cut conduit openings in freezer and cooler walls, floor, and ceilings, in accordance with manufacturers' instructions, when openings are not provided by the manufacturers. Seal around conduit penetrations air tight with an approved pliable material suitable for low temperatures. Effectively seal interiors of conduits, by installing a conduit fitting at the boundary of the two spaces, and filling it with an approved pliable material, after conductors or cables have been installed and tested.

G. Provide all grounding systems as required by the equipment supplier.

3.7 DOOR OPERATORS AND HARDWARE

A. Provide electrical connections to automatic entry doors, automatic corridor doors, electrically held door latches, remote release doors, and all other required electrical connections for door systems included in other sections of these specifications.

B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.

C. Provide all control wiring and conduit for all equipment that is not included within the responsibility of the door hardware installer. Provide connection from junction boxes to the door operators or hardware and from door operators to actuation devices as required. Install key operated switches, push pad switches, and other electrically controlled door operation devices furnished by other divisions within this contract.

D. Provide fire alarm devices and wiring as required for proper operation of door systems in accordance with the NFPA codes.

3.8 SIGNAGE AND WAYFINDING

A. Provide junction boxes, disconnect switches and grounding per manufacturer's installation drawings.

B. Coordinate rough-in requirements with signage installation instructions.

C. Coordinate box locations and conduit routing with parapets and roof elevations.

D. Provide labelling on all junction boxes and disconnects in accordance with Division 26 section "Identification for Electrical Systems"

END OF SECTION 260502

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:
1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Aetna Insulated Wire Co.
2. AFC Cable Systems, Inc.
3. American Insulated Wire Corp.
4. Anixter, Inc.
5. Cablec Industrial Cable Co.
6. Essex Group, Inc.
7. The Kerite Co.
8. The Okonite Co.
9. Pirelli Cable Corp.
10. Southwire Co.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN, UF, and SO.

D. Multiconductor Cable: Comply with NEMA WC 70 for Type SO.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Advance Products & Systems, Inc.

2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.
5. 3M; Electrical Products Division.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM NBR or interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Carbon steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders and Branch Circuits: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders and Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

G. Class 1 Control Circuits: Type THHN-THWN, in raceway.

H. Class 2 Control Circuits: Type THHN-THWN, in raceway, Power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Complete cable tray systems installation according to Division 26 Section “Cable Trays for Electrical Systems” prior to installing conductors and cables.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
1. For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2. For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 26 Section " Common Work Results for Electrical."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

End of Section

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
Test wells.
Ground rods.
Ground rings.
Grounding arrangements and connections for separately derived systems.

C. Field quality-control reports.

D. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
Instructions for periodic testing and inspection of grounding features at test wells based on NETA MTS.
1. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2. Include recommended testing intervals.
3. Include plans showing as-built, dimensioned locations of grounding features specified in “Field Quality Control” Article, including the following:
   a. Test wells
   b. Ground rods
   c. Ground rings
   d. Grounding arrangements and connection for separately derived systems.
4. Instructions for periodic testing and inspection of grounding features at test wells based on NETA MTS.
   a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
   b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with NECA 331 for building and service entrance grounding and bonding.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
Solid Conductors: ASTM B 3.
Stranded Conductors: ASTM B 8.
Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Power and Communications Grounding Bus: As indicated on drawings. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

D. Isolated Grounding Conductors: Green-colored insulation with continuous yellow strip. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless irreversible, compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

E. Irreversible Connectors Compression connectors of pure wrought copper, per ASTM B187.
Cast connectors of copper base alloy per ASTM B30. Pre-fill connectors with a corrosion inhibiting compound which is compatible with the conductors being joined. Provide connectors equivalent in current carrying capacity to the maximum size copper conductors being joined.

Clearly and permanently mark connectors with the following information:
1. Catalog number.
2. Conductors accommodated.
3. Installation die index or die catalog number is required.
4. Underwriters Laboratories “Listing Mark”.

5. The words “Direct Burial” or “Burial” per UL 467.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch in diameter by 10 feet long (19 mm by 3 m).

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
Bury at least 24 inches (600 mm) below grade.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:
Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
Underground Connections: Welded connectors except at test wells and as otherwise indicated.
Connections to Ground Rods at Test Wells: Bolted connectors.
Connections to Structural Steel: Welded connectors.

3.2 POWER SYSTEM GROUND

A. Ground the electric service system neutral at service entrance equipment to grounding electrodes, per NFPA 70.

B. Ground separately-derived ac power system neutrals, including distribution transformers, and uninterruptible power supplies to grounding electrodes, per NFPA 70.

C. Separately ground the emergency generator neutral to grounding electrodes, per NFPA 70.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor.

Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a grounding bus.
Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or 24 inches (600 mm) below final grade unless otherwise indicated.
Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Ground Ring: Install a grounding conductor, electrically connected to the wing three renovation around the perimeter of the wing three renovation. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for connections to building service entrance ground. Bury ground ring not less than 24 inches (600 mm) from building's foundation. Provide test wells at ends of ring to be extended under future renovations.

3.6 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Ground bars shall be labeled along with each conductor connected to it noting what the conductor is connected to.

C. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:
After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
1. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
2. Perform tests by fall-of-potential method according to IEEE 81.
Prepare dimensioned Drawings locating each interior and exterior ground bar, test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports. Include test and inspection reports in operation and maintenance manual.

D. Report measured ground resistances that exceed the following values:

Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
Substations and Pad-Mounted Equipment: 5 ohms.
Manhole Grounds: 10 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

End Of Section

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   a. Hangers and supports for electrical equipment and systems.
   b. Construction requirements for concrete bases.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized (G90).

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1) Hilti Inc.
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
Toggle Bolts: All-steel springhead type.
Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

Secure raceways and cables to these supports with single-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

To Wood: Fasten with lag screws or through bolts.
To New Concrete: Bolt to concrete inserts.
To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
To Existing Concrete: Expansion anchor fasteners.
Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts. Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
To Light Steel: Sheet metal screws.
Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base. Construct base with 4" height minimum or as indicated on drawings.

B. Use 4000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Provide rebar to anchor concrete base to floor.

3.5 SERVICE CARRIERS

A. Construct service carriers with metal framing ("Unistrut") to support surface raceway. Service carriers shall be braced to ceiling with diagonal metal framing supports to prevent swaying. Provide all accessories, connectors, channel nuts, etc. for a complete system. Coordinate with NIST on standard detail for typical service carrier.

End Of Section

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
1. Custom enclosures and cabinets.
2. For handholes and boxes for underground wiring, including the following:
   a. Duct entry provisions, including locations and duct sizes.
   b. Frame and cover design.
   c. Grounding details.
   d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
   e. Joint details.

C. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

D. EMT: ANSI C80.3.

E. FMC: Zinc-coated steel

F. LFMC: Flexible steel conduit with PVC jacket.

G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Fittings for EMT: Steel or die-cast, compression type.
2. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

H. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

B. ENT (Electrical Nonmetallic tubing): NEMA TC 13.

C. RNC (Rigid Nonmetallic Conduit): NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC (Liquid-tight Flexible Nonmetallic Conduit): UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

G. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.3 METAL WIREWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 3R, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type.

E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.

11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Metal Floor Boxes: Cast or sheet metal], fully adjustable, rectangular.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

I. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.
1. Color of Frame and Cover: Green.
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, as indicated for each service.
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
a. Armorcast Products Company.
b. Carson Industries LLC.
c. CDR Systems Corporation.
d. NewBasis.
e. Quazite

2.7 SLEEVES AND SLEEVE SEALS FOR RACEWAYS

A. Division 26 Section "Sleeves and sleeves seals for electrical raceways for electrical systems" for sleeves required for penetrations.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 26 Section "Common Work Results for Electrical."

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit, EMT.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
5. Application of Handholes and Boxes for Underground Wiring:
   a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
   b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
   c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): use LFMC.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Plenum-type, optical fiber/communications cable raceway
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: Plenum-type, optical fiber/communications cable raceway.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
11. Conduit color: Conduit color shall match site standard color requirements for entire length of run from main switchboard to device, including to pull boxes as described in Section 26 “Identification for Electrical Systems”. This includes conduits for feeders to transformers, panelboards, and distribution boards. Contractor shall submit a marked up one-line diagram noting color of conduits and equipment/circuit breaker labels for NIST review/approval. Conduits shall be painted by

manufacturer. No contractor painting on site will be allowed. Refer to NIST Color Chart for color requirements associated with each system.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size for power and 1-inch (27-mm) trade size for telecommunication.

D. Raceway Fittings: Compatible with raceways and suitable for use and location. Set screw fittings are not permitted.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are required.

G. Set screw fittings are not permitted. Contractor shall only use compression fittings.

H. Conduits within finished areas shall be concealed in walls, ceilings, and floors, unless otherwise indicated. Finished areas consist of labs, offices, break rooms, public corridors, conference rooms, lobbies, and other public areas. Conduits can be exposed in mechanical, electrical rooms, MDF/IDF rooms, and service galleys. Coordinate other areas not listed with the COR prior to bid.

I. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Change conduits in slab to PVC coated rigid steel conduit before rising above the floor.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

L. Install pull wires in all empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

M. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
   1. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
   2. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
   3. Provide the necessary quantity of conduits for communication cables as required to each location.

N. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

O. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
      c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
      d. Attics: 135 deg F (75 deg C) temperature change.
   2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
   3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

P. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC in damp or wet locations not subject to severe physical damage.

Q. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

R. Set metal floor boxes level and flush with finished floor surface.

S. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 26 Section " Common Work Results for Electrical."

3.4 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

End Of Section

SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:
1. Division 26 Section "Common Work Results For Electrical Systems" for penetration firestopping.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

1.5 QUALITY ASSURANCE

A. Coordinate sleeve selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Sleeves for Rectangular Openings:
1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved substitute:
a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.
e. Proco Products, Inc.
f. Or as approved.
2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved substitute:
a. Presealed Systems.
b. Or as approved.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Fire-Rated Assemblies: Install sleeves for penetration of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. De-burr after cutting.

E. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

F. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

G. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

H. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

End Of Section

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. **Contractor shall refer to the most recent version of NIST's Electrical Naming Convention document for the site standard on electrical equipment designations**.

1.2 SUMMARY

A. Section Includes:
1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type/size and color of label used in project.

1.5 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.6 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Install identifying devices upon completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.7 COLOR CODING

A. Conduits shall be color coded (painted by conduit manufacturer). Provide color coding for the entire length of run from main switchboard to device, including to pull boxes. This includes conduits for feeders to transformers, panelboards, and distribution boards. Contractor shall submit a marked up one-line diagram noting color of conduits and equipment/circuit breaker labels for NIST review/approval. Refer to NIST Color Chart for color requirements associated with each of the following systems:
1. Grey: Normal Branch power systems branch (house power).
2. Red: Fire alarm system equipment.
3. Yellow: Emergency Life safety NEC 700/701 branch
4. Green: Emergency optional standby NEC 702 branch (mechanical equipment)
5. Orange: Emergency optional standby NEC 702 branch. (telecom equipment)
6. White: Research/Lab normal power branch
7. Black: Research/Lab back up power system branch associated with generator or uninterruptible power supply systems.
8. Blue: Mechanical controls.
9. Purple: Security Systems

B. Visually Controlled Exposed Construction
1. In spaces where the finish Exposed Construction – Architectural is indicated, in place of the standard conduit identification markers specified, install markers consisting of black letters on a clear background, located on the top center line of conduit. Provide “OPTI-CODE’ pressure sensitive vinyl identification markers by Seton or equivalent product by Brady or Marking Services.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
1. Entire length of conduit run along with devices and pull boxes as specified in color coding section of this specification.

C. Tag colors for Raceways Carrying Circuits at 600 V or less:
1. Refer to color requirements as noted in the Equipment Identification Labels section.
2. Legend: Indicate voltage and system or service type.

D. Tag colors for Raceways Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.

2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.

E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

F. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

G. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.2 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.3 FLOOR MARKING TAPE

A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.4 UNDERGROUND-LINE WARNING TAPE

A. Tape:
1. Printing on tape shall be permanent and shall not be damaged by burial operations.
2. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils. Tape shall be detectable by a metal detector.

B. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Multilayer Laminate:
1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 12 mils (0.3 mm).
3. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).

2.5 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Laminated as-built drawings of the project's one-line diagrams in 24" by 18" frames shall be mounted inside each electrical room. The frames shall be mounted adjacent to the main entrance of the electrical room.

C. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

D. Baked-Enamel Warning Signs:
1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

E. Metal-Backed, Butyrate Warning Signs:
1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

F. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. 208Y/120V Panel Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
3. 480Y/277V Panel Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (1219 MM)."
4. Arc Flash Warning “ARC FLASH AND SHOCK HAZARD APPROPRIATE PPE REQUIRED” Provide the appropriate equipment labels which indicate the flash protection hazard risk category, incident energy, flash protection boundary, PPE list, and date when study was performed. Refer to section 26 05 73 “OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY” for study requirements. Label shall match NIST Site Standard Arc Flash Label.

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic/Phenolic Label: Adhesive backed. Minimum letter height shall be 3/8 inch (10 mm). Labels shall be able fit on device cover plates, disconnect switches, transformers, panelboards, etc.

B. Label colors shall match NIST Color Chart requirements and be:
1. Normal Branch devices/equipment - Grey label with white lettering,
2. Life Safety devices/equipment - Yellow label with black lettering,
3. Normal Research devices/equipment - White label with black lettering,
4. UPS/Generator Research devices/equipment - black label with white lettering,
5. Telecomm Branch devices/equipment on Generator Power - Brown label with white lettering.
6. Devices/equipment on Generator Power – Green label with white lettering.
7. Mechanical controls – Blue label with white lettering.
8. Fire Alarm/VESDA – Red with white lettering.
9. Security Systems – Purple with white lettering.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black except where used for color-coding.

B. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
   5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color-Coding for Raceways: Manufactured applied paint. No painting of conduits on site.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE

WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways More Than 600 V: Snap-around labels. Install labels at 10-foot (3-m) maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot (10-m) maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. Labels shall be color coded as noted above. System legends shall be as follows:

1. Emergency Power.
2. Power
3. Research Power – Normal
4. Research Power – Generator/UPS
5. Fire Alarm
6. Life Safety
7. Security
8. Telecomm

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding as specified below to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded services, feeders and branch-circuit conductors.
   a. Color shall be factory applied for sizes No. 8 AWG and smaller.
   b. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
   c. Colors for 208/120-V Circuits:
      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.
   d. Colors for 480/277-V Circuits:
      1) Phase A: Brown.
      2) Phase B: Orange.
      3) Phase C: Yellow.
   e. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

1. Color-coding for Phase Identification, More than 600V: Use colors listed below for ungrounded services and feeders.
   a. Color shall be field applied with color-coding conductor tape. Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes, manholes, equipment, etc. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

b. Colors shall be:
   1) Phase A: Red.
   2) Phase B: Yellow.
   3) Phase C: Blue.

G. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
   1. Install underground-line warning tape for both direct-buried cables and cables in raceway.

J. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels or baked-enamel warning signs or metal-backed, butyrate warning signs.
   1. Comply with 29 CFR 1910.145.
   2. Identify system voltage with black letters, on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.

L. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

M. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with drawings, wiring diagrams, and schedules. Apply labels to equipment and systems listed below including central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters for each unit of identifying information. on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
      d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

e. Provide equipment designations consistent with drawings (e.g., "RP-A") and source(s) of power (e.g., Fed from DP-A). The label shall indicate the panelboard/switchboard and circuit number feeding the equipment

2. Equipment to Be Labeled:
   a. Fire Alarm Panels.
   b. Security Panels.
   c. Contactors.
   d. Control panels (e.g., fire alarm, security, lighting control systems, etc.)
   e. Generators
   f. Ground bars
   g. Uninterruptible Power Supply Systems
   h. Emergency system boxes and enclosures.
   i. Enclosed circuit breakers.
   j. Enclosed controllers.
   k. Enclosed switches.
   l. Enclosures and electrical cabinets.
   m. Monitoring and control equipment.
   n. Motor-control centers.
   o. Panelboards: Label that includes tag designation shown on Drawings and "Fed from . . . ."
   p. Panelboard Directories: Typewritten directory of circuits in the location provided by panelboard manufacturer.
   q. Substations.
   r. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   s. Power transfer equipment.
   t. Push-button stations.
   u. Switchboards.
   v. Switchgear.
   w. Variable-speed controllers.

End Of Section

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Provide wiring devices as specified and indicated.

B. Related Sections include the following:
   1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Heavy-duty Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following or approved substitute (The "X" in the following series numbers represents the amperage as specified):
      a. Bryant 5X62
      b. Cooper 5X62
      c. Hubbell HBL 5X62
      d. Leviton 5X62
      e. Pass & Seymour 5X62

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
   1. Provide "feed-through" type capable of protecting connected downstream receptacles on a single circuit.
   2. Provide device with integral diagnostic indication for miswiring (i.e. line/load reversal) which prevents the receptacle from resetting.
   3. Provide shallow depth design to permit installation in a 70-mm-deep (2-3/4-inch-deep) outlet box.
   4. Products: Subject to compliance with requirements, provide one of the following or approved substitute:
      a. Cooper Wiring Devices
      b. Pass & Seymour Inc.: Safe Lock series
      c. Hubbell, Inc.: GF-5X52 series
      d. Leviton Mfg. Co.: Smartlock series

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following or approved substitute:
      a. Cooper; L520R.
      b. Hubbell; HBL2310.
      c. Leviton; 2310.
      d. Pass & Seymour; L520-R.

2.5 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
   1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 SNAP SWITCHES

A. Description: Heavy-duty construction, totally enclosed, thermoset material, construction base and cover, quiet type toggle handle, rated 120-277 volts AC and 20 amperes, silver alloy contacts, equipped with insulated mounting yoke, plaster ears, side and rear wiring terminals, and ground wire thermal.

B. Provide one-pole, two-pole, three-way, and four-way switches as indicated.

C. Comply with NEMA WD 1 and UL 20.
1. Products: Subject to compliance with requirements, provide one of the following or approved substitute:
a. Bryant; 4900 series
b. Cooper; 222X series, 2224 (four way).
c. Hubbell;122X series.
d. Leviton; 1221-2.
e. Pass & Seymour;PS20AC series.

2.8 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location in-use, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.9 MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. MonoSystems, Inc.
3. Wiremold Company (The).

B. General
1. Wiremold ALA4800 Series (Two-Channel) or ALA3800 Series (Single-Channel) Isoduct Aluminum raceway or approved substitute. Clear anodized finish, with devices, junction fittings and other matching accessories as required for a complete system and per UL 5.
2. Provide multi-outlet assembly with devices evenly spaced along its length. The maximum allowable distance from an end of the raceway to the first device in one-half the specified device spacing.
3. Provide continuous one-piece cover plates, minimum four-feet long.

C. Surface Raceway
1. Each channel shall have its own separate cover. A single cover that covers two or more channels is not acceptable.
2. Three-channel, Multioutlet assembly
a. One channel with normal power for single 20-ampere, 125-volt, 2-pole, 3-wire receptacles on 24-inch centers, alternately connected to three 20-ampere, 125-volt circuit with ground. Confirm quantity and spacing of receptacles with NIST prior to ordering.
b. One channel with optional standby power for single 20-ampere, 125-volt, 2-pole, 3-wire receptacles on 24-inch centers, alternately connected to three 20-ampere, 125-volt circuit with ground. Confirm quantity and spacing of receptacles with NIST prior to ordering.
c. One channel for communications horizontal cabling. Confirm quantity and spacing of communication knock-outs prior to ordering.
d. In order to achieve the three-channel raceway, contractor shall provide a two-channel and single-channel raceway.

D. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

2.10 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color. Refer to NIST Color Chart.
1. Wiring Devices Connected to Normal Power System in lab spaces (Research Power): White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Normal Power System outside of lab spaces (House Power): Grey, unless otherwise indicated or required by NFPA 70 or device listing.
3. Wiring Devices Connected to generator/UPS in lab spaces (Back-Up Research Power): Black, unless otherwise indicated or required by NFPA 70 or device listing.
4. Wiring Devices Connected to Optional Standby Power System (NEC 702), feeding equipment: Green, unless otherwise indicated or required by NFPA 70 or device listing.
5. Wiring Devices Connected to emergency (life safety) Power System (NEC 700 and 701): Yellow, unless otherwise indicated or required by NFPA 70 or device listing.
6. Wiring Devices Connected to Optional Standby Power System (NEC 702), feeding telecommunication equipment: Orange, unless otherwise indicated or required by NFPA 70 or device listing.
7. Wiring Devices Feeding Mechanical Controls: Blue, unless otherwise indicated or required by NFPA or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Prior to installation of devices, verify wall openings are neatly cut and will be completely covered by wall plates, clean debris from outlet boxes and provide extension rings to bring outlet boxes flush with finished surface.

C. Install devices and assemblies level, plumb, and square with building lines.

D. Install wall dimmers to achieve full rating specified and indicated after derating for ganging according to manufacturer's written instructions.

E. Coordination with Other Trades:

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

F. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

G. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

H. Device Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.
2. Install GFCI receptacles so that the “Push To Test” and “Reset” designations can be read correctly. If printed in both directions, install with ground pole on top.
3. Install switches with OFF position down.

I. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

J. Dimmers:
1. Install dimmers within terms of their listing.
2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

K. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

L. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

M. Coordinate installation of access floor boxes with access floor system provided by Architectural trades.

N. Install properly oriented access floor boxes into cutouts in access floor tiles and secure to tiles per Manufacturer's instructions.

O. Adjust devices and wall plates to be flush and level. Three corners of wall plates must be in contact with wall surfaces. Devices shall be solidly mounted against the box.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
   1. Wiring Devices (receptacles, switches, occupancy sensors, light switches, receptacles in multioutlet assemblies, etc.): Identify panelboard and circuit number from which served. Use engraved labels with hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes. Labels shall meet NIST site standard color requirements. Refer to NIST Color Chart.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Inspect each wiring device for defects.
   2. Operate each wall switch with circuit energized and verify proper operation.
   3. After installing wiring devices and after electrical circuitry has been energized, test each receptacle for proper polarity, ground continuity, and compliance with requirements.
   4. Test each GFCI receptacle for proper operation with both local and remote fault simulations according to manufacturer's written instructions.
   5. Test Instruments: Use instruments that comply with UL 1436.
   6. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

D. Test straight blade for the retention force of the grounding. Retention force shall be not less than 4 oz. (115 g).

E. Contractor shall ensure that all surface raceway covers match and inspect before installation. Manufacturer shall provide replacement covers to ensure entire raceway system matches. NIST will not accept mismatch covers or painted covers.

F. Contractor shall perform all field-cuts with precision. NIST will not accept gaps between covers. Contractor will provide replacement covers as required to ensure an acceptable installation.

End Of Section

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Cartridge fuses rated 600-V ac and less.
2. Plug fuses rated 125-V ac and less.
3. Spare-fuse cabinets.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 QUALITY ASSURANCE

A. NIST to witness all field quality control tests, start up of equipment, and attend construction meetings.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA FU 1 for cartridge fuses.

E. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.7 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than **one** set of three of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following or approved substitute:
   1. Cooper Bussmann, Inc.
   2. Edison Fuse, Inc.
   3. Ferraz Shawmut, Inc.
   4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 PLUG FUSES

A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.4 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Provide fuses from the same manufacturer to insure retention of selective protective device coordination.
   2. Fuses rated 600 amperes and less: UL Class RK1 unless otherwise indicated or specified, current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms.
      a. Provide UL Class RK5 fuses current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms, as follows:
         1) Motor starters size 3 and smaller.
         2) Panelboard main fuses where the amperage ratio between the main fuse to the largest feeder fuse is at least 2:1.
   3. Fuses rated greater than 600 amperes: UL Class L, current-limiting, per UL 198C, with an interrupting rating of 200,000 amperes RMS.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s). Coordinate final location with NIST.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

End Of Section

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

B. **Contractor shall refer to the most recent version of NIST's Electrical Naming Convention document for the site standard on electrical equipment designations**.

1.2 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
1. Wiring Diagrams: For power, signal, and control wiring.

C. Field quality-control reports.
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.4 QUALITY ASSURANCE

A. NIST to witness all field quality control tests, start up of equipment, and attend construction meetings.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Owner no fewer than 30 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.
5. Provide temporary power, lighting, heating, cooling, and ventilation.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.7 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, unless otherwise indicated, 240-v or 600-v ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Features:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

D. Accessories:
1. Hookstick Handle: Allows use of a hookstick to operate the handle.
2. Disconnect switches serving variable frequency controllers: Provide electrical interlock kit to break the control circuit before the main switch blades break.

E. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

F. Type HD, Heavy-Duty, Single-Throw, unless otherwise indicated, 240 or 600-V ac, amperage as indicated; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

2.2 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Electronic Trip for circuit-breaker frame sizes 250 A and larger.

D. Electronic Trip Circuit Breakers: For circuit-breaker frame sizes 250 A and larger: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

G. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.3 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved substitute:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features:
1. Standard frame sizes and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

D. Accessories:
1. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
2. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
3. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1, unless otherwise indicated.
2. Outdoor Locations: NEMA 250, Type 3R, unless otherwise indicated.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel, unless otherwise indicated.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4, unless otherwise indicated.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with laminated-plastic nameplate. The nameplate shall indicate the panelboard/switchboard and circuit number feeding the disconnect switch or enclosed circuit breaker. Label color shall match NIST site standard. Refer to NIST Color Chart.

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
      c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study". Coordinate final inspection with NIST to confirm settings.

End Of Section

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes lightning protection for structures.

1.3 BUY AMERICAN ACT REQUIREMENTS:

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For air terminals and mounting accessories.
1. Layout of the lightning protection system, along with details of the components to be used in the installation.
2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.

B. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

C. Field quality-control reports.

D. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.

E. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
1. Ground rods.
2. Ground loop conductor.
3. Test wells and inspection wells for ground loop conductor.

F. Provide all submittals and final installation drawings in the operational and maintenance manual.

1.6 QUALITY ASSURANCE

A. NIST to witness all field quality control tests, start up of equipment, and attend construction meetings.

B. Installer Qualifications: Certified by UL trained and approved for installation of units required for this Project.

C. System Certificate for wing three's system:
1. UL Master Label.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.7 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

D. Coordinate the locations and installation of conduits for down conductors with all trades.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96 and NFPA 780.

B. Roof-Mounted Air Terminals: NFPA 780, Class I aluminum unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved substitute:
a. East Coast Lightning Equipment Inc.
b. ERICO International Corporation.
c. Harger.
d. Heary Bros. Lightning Protection Co. Inc.
e. Independent Protection Co.
f. Preferred Lightning Protection.
g. Robbins Lightning, Inc.
h. Thompson Lightning Protection, Inc.
2. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
3. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07 roofing Sections.

C. Main and Bonding Conductors: Aluminum.

D. Ground Loop Conductor: #4/0 tinned copper.

E. Ground Rods: Copper-clad 3/4 inch (19 mm) in diameter by 10 feet (3 m) long.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

C. There shall be no exposed down conductor conduits on the exterior of the building. All down conductors shall be routed through the building in PVC conduits and tied to the ground ring below finished grade. The PVC conduits shall be concealed when routed in finished areas. NIST will not accept any exposed conduits in finished areas.

D. Install PVC sleeves within foundation for routing of grounding conductors from the interior of the building to the building's exterior buried ground ring.

E. Provide required hardware for lightning protection system, including but not limited to:
1. Flashing.
2. Conduit supports.
3. Conductor supports.
4. Bonding conductors.

F. Conceal the following conductors:
1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.

G. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

H. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

I. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

J. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.

K. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of area or item indicated.
1. Bury ground ring not less than 24 inches (600 mm) from building foundation.
2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet (3.6 m) of grade level.
4. Provide a minimum of two test wells at opposite sides of the loop. Provide test wells at points of the loop to be extended under renovation of the remaining wings.

L. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.

M. Coordinate with the roof manufacturer for the requirement of supplemental roofing materials beneath ground conductors installed on roof. Change orders will be rejected.

N. Label the ground conductor that connects to the main electrical ground buss in the electrical room.

O. The Master Label certificate is required for NIST OFPM to receive the Temporary Certificate of Occupancy/Certificate of Occupancy. Contractor shall schedule the final test and submit the certificate prior to Substantial Completion.

P. If roof has fall protection railing system, it shall be bonded to the lightning protection system.

3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Notify Architect and NIST at least 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

End Of Section

SECTION 27 05 26

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Grounding/Earthing and bonding for Low Voltage systems such as telecommunications and audiovisual systems.
2. Telecommunications Grounding Busbar (TGB)
3. Telecommunications Main Grounding Busbar (TMGB)
4. Telecommunications Bonding Backbone (TBB)
5. Rack Grounding/Earthing and Bonding
6. Pathways.

B. Related Sections:
1. Division 26 Section *Grounding and Bonding* for building systems with which to interface Work of this Section.

1.2 BUY AMERICAN ACT REQUIREMENTS

A. This contract is subject to the Buy American Act and as required by that Act. Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.3 DEFINITIONS

A. AFC: Above Finished Ceiling

B. BICSI: Building Industry Consulting Service International.

C. Bonding: Permanent joining of metallic parts to form an electrically conductive path to ensure electrical continuity and capacity to safely conduct current.

D. Common Bonding Network (CBN) – The principal means for affecting bonding and earthing inside a building.

E. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

F. EMI: Electromagnetic interference.

G. Ground/Earth – A conducting connection, whether intentional or incidental, by which an electric circuit or equipment is connected to ground, or to some conducting body of relatively large extent that serves in place of the ground.

H. HC: Horizontal Cross Connect

I. IDC: Insulation displacement connector.

J. IDF: Intermediate Distribution Frame

K. LAN: Local Area Network.

L. MC: Main Cross-connect

M. MDF: Main Distribution Frame

N. NEBS: Network Equipment Building System.
   1. NEBS Level 3: Equipment complies with strict specifications for fire suppression, thermal margin testing, vibration resistance including seismic, airflow patterns, acoustic limits, failover and partial operational requirements such as chassis fan failures, failure severity levels, RF emissions and tolerances, and testing/certification requirements.

O. NEC: National Electric Code

P. RCDD: Registered Communications Distribution Designer.

Q. UTP: Unshielded twisted pair.

1.4 SYSTEM DESCRIPTION

A. Provide a complete and functioning Telecommunications grounding/earthing system inclusive of all hardware, software and training to meet or exceed the performance features outlined in this document.

B. Purpose: Telecommunications grounding/earthing system creates a low impedance path to earth ground to prevent damage to equipment and disruption in service due to electrical surges and transient voltages.

C. Grounding/earthing system comply with following:
   1. NEC and local electrical codes
   2. ANSI/TIA-942 and J-STD-607-A.
   3. IEEE 1100

D. Telecommunications Grounding Busbar (TGB): Ground/earth each telecommunications space to the Telecommunications Main Grounding Busbar (TMGB) located at the service entrance.

1.5 SUBMITTALS

A. Comply with Division 01330 Section *Submittal Procedures*.

B. Submittal data is to be submitted in a three ring binder, a continuous spiral binder, or plastic binding that allows the booklet to lie flat while open. Each booklet shall contain the below in the following order:
   1. Cover Sheet.
      a. Include name of supplying contractor and project name.
   2. Detailed Bill of Materials.
      a. Include a listing of: component quantities, equipment manufacturer, model number, and description of each component being supplied, and the specification paragraph or drawing sheet that corresponds to the product. Failure to provide this information will result in the rejection of submittals.
   3. Product Data.
      a. Include a catalog sheet per product of equipment listed in the Detailed Bill of Materials, in the exact order as the Detailed Bill of Materials. Each catalog sheet shall describe mechanical, electrical and functional equipment specifications. The catalog sheet must also include a image of the product. Photocopy duplications of the manufacturer's original equipment catalog sheets will be allowed as long as they provide adequate clarity of both the printed word and

graphics/pictures. If more than one product is shown on the catalog sheet the intended product must be denoted by either an arrow or highlight.

C. Shop Drawings
1. Wiring diagram to show grounding schematics, including the following: Busbars and bonding backbone. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
2. Show the relationship of the MDF and IDF rooms, the pathway between them, and cable connectivity to be installed.
3. Drawings should be at project standard scale clearly legible.

1.6 CLOSEOUT SUBMITTALS

A. At the completion of the installation, but before Final Acceptance, provide for review and approval the following, in compliance with Division 1 Section *Closeout Procedures*.
1. Operation and Maintenance Manuals:
a. Equipment manufacturers operation and service manuals for each make and model of equipment.
b. System Operation Manual. Produce a manual specifically for the subsystems detailed herein. The manual shall describe all procedures necessary to activate each system to provide for the functional requirements, except as specifically excluded by the Owner. This section shall provide a simple "How-to" users guide for the procedures needed to operate the systems.
c. Include all testing procedures and test results for all equipment associated with these subsystems as a part of the Operation and Maintenance Manuals.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements, grounding/earthing and bonding systems:
1. TIA/EIA
a. TIA-942 Telecommunications Infrastructure Standard for Data Centers
b. J-STD-607-A Commercial Building Grounding/Bonding Requirements
c. TIA/EIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
2. IEEE
a. Std 1100 IEEE Recommend Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book)
3. Telcordia:
a. NEBS 3 as defined for RBOC-CO compliance.
4. NFPA
a. NFPA-70 National Electric Code (NEC)
5. ECA-BICSI
a. ECA-BICSI-607-2011 Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings

B. Testing Procedures:
1. NEBS GR-63-CORE: Network Equipment-Building System Requirements: Physical Protection.
2. NEBS GR-1089-CORE: Electromagnetic Compatibility and Electrical Safety -- Generic Criteria for Network Telecommunications Equipment

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers, Grounding/Earthing Systems:
1. Panduit

2. Chatsworth
3. Harger
4. Burndy
5. Ortronics/Legrand
6. Erico

B. Acceptable Manufacturers, Telecommunications Grounding Busbar:
1. Panduit
2. Chatsworth
3. Harger
4. Burndy
5. Ortronics/Legrand
6. Erico

C. Acceptable Manufacturers, Rack Grounding Kits:
1. Panduit
2. Chatsworth
3. Harger
4. Burndy
5. Ortronics/Legrand
6. Erico

2.2 GROUNDING/EARTHING AND BONDING

A. General:
1. Conductors: Provide copper grounding/earthing conductors.
2. Lugs, grounding strips, and busbars: UL Listed. Fabricate with premium quality tin-plated electrolytic copper, providing low electrical resistance while inhibiting corrosion. Provide antioxidant for field- bonding connections.
3. Lugs: NEBS Level 3. Provide two-hole lugs with irreversible compression and inspection windows, certified for use in non-corrosive environments so that connections may be inspected for full conductor insertion.
4. Die index numbers: Embossed on compression connections to allow crimp inspection.
5. Cable assemblies: UL Listed and CSA Certified.
   a. Cables: Green or green/yellow.
   b. Jackets: UL Listed, VW-1 flame rated.

B. Telecommunications Bonding Backbone (TBB): At cable used to ground/earth TGB; comply with J-STD-607-A guidelines and provide gauge not lighter than the following:

Sizing of the TBB	
TBB Length in Linear meters (feet)	TBB Size (AWG)
Less than 4 (13)	6
4-6 (14-20)	4
6-8 (21-26)	3
8-10 (27-33)	2
10-13 (34-41)	1
13-16 (42-52)	1/0
16-20 (53-66)	2/0
Greater than 20 (66)	3/0

C. Grounding Cable, Typical: For applications other than TBB, provide gauge not lighter than the following:

Cable Sizes for Other Grounding/Earthing Applications	
Purpose	Copper Code Cable Size
Aisle grounds (overhead or under floor) of the common bonding network	#2 AWG or larger (1/0 preferred)
Bonding conductor to each PDU or panel board serving the room.	Size per NEC 250.122 & manufacturer recommendations
Bonding conductor to HVAC equipment	6 AWG
Building columns	4 AWG
Cable ladders and trays	6 AWG
Conduit, water pipe, duct	6 AWG

2.3 COMPONENTS, KITS AND HARDWARE

A. Provide BICSI/J-STD-607-A telecommunications grounding busbars for the TMGB. Locate TMGB at AC service entrance.

B. Provide BICSI/J-STD-607-A telecommunications grounding busbars for the TGB at typical telecommunications/equipment spaces throughout the building.

C. Provide compression type two hole lugs for connecting conductors to TMGB and TGB.

PART 3 - EXECUTION

3.1 ROUTING TBB AND TGB

A. Route the TBB to each TGB in as straight a path as possible. The TBB should be installed as a continuous conductor, avoiding splices where possible. When more than one TBB is used, bond them together using the TGBs on the top floor and every third floor in between with a conductor known as a Grounding Equalizer (GE). Use the J-STD-607-A guidelines for sizing of the TBB when sizing the GE (shown in the table above).

B. Avoid routing grounding/earthing conductors in metal conduits. If the grounding/earthing conductor must be routed through a metal conduit, bond each end of the conduit to the grounding/earthing conductor. Use grounding clamps to bond to the conduit and #6 AWG copper conductor to connect the grounding clamp to the GB.

3.2 RACK GROUNDING/EARTHING

A. Bonding Equipment and Racks: Comply with ANSI/TIA-942.

B. To provide electrical continuity between rack elements, use paint piercing grounding washers where rack sections bolt together, on both sides, under the head of the bolt, and between the nut and rack.

C. Utilize full-length rack ground strips attached to the rear of the side rail with thread-forming screws provided to ensure metal-to-metal contact.

D. Mount an electrostatic discharge (ESD) port kit, directly to the rack grounding strip on the back of the rack at approximately 48 inches from the floor. Mount a second electrostatic discharge (ESD) port kit directly to the vertical mounting rail of the rack in the front at approximately the same height. Use the thread-forming screws provided to form a bond to the rack.

E. When the equipment manufacturer provides a location for mounting a grounding connection, that connection shall be utilized. Use the appropriate jumper for the equipment being installed and the thread-forming screws provided in the kit.

F. Do not bond racks or cabinets serially.

G. Bond patch panels to racks using bonding screws.

H. Label Grounding Bus Bars to match designations shown on Telecommunciations drawings.

3.3 TESTING

A. Perform continuity testing measurements of the grounding system with resistance to not exceed 0.1 ohm between:
   1. The TMGB and the nearest grounding electrode.
   2. Each TGB and the nearest grounding electrode.
   3. Each TGB and pathway(s), rack(s), cabinet(s), and applicable equipment.

3.4 GROUNDING SYSTEM

A. Communications grounding system: Comply with ANSI/TIA-942 and J-STD-607-A.

B. Connection to Building ground/earth: Ensure connection is made by a licensed, electrical Installer, including installation and termination of the main bonding conductor to the building service entrance ground.

C. Bond TMGB to building steel; ground/earth to electrical service ground specified in Section 27 05 26. Comply with BICSI TDM Manual and J-STD-607-A guidelines.

End of Section

SECTION 27 05 28.36

CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Continuous, cable tray system used in industrial, commercial, and telecommunications applications.

B. Cable tray systems are defined to include, but are not limited to, straight sections, supports and accessories.

1.2 BUY AMERICAN ACT REQUIREMENTS

A. This contract is subject to the Buy American Act and as required by that Act. Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.4 SUMMARY

A. Related Sections:
1. Division 27 00 00 Telecommunications Cabling Systems for voice and data cabling associated with system panels and devices.

B. Bidding Requirements:
1. Submit complete detailed proposals with line item cost representation for components and associated installation labor. Lump sum bids will not be accepted.
2. Include as part of the bid response the following items:
3. Installation schedule with proposed manpower assignments.
4. Resumes for project manager and lead technician for this project.
5. Review associated “Electrical” and “Telecommunication” Series drawings to verify the necessary conduit, floor boxes, devices, etc. required. Understand and coordinate shared infrastructure locations for A/V and voice/ data outlets. Any discrepancies with the identified infrastructure to support these systems should be questioned in the form of a request for information (RFI) during the bidding process. Be responsible for any additional infrastructure requirements after receipt of contract for this project. There will be no change orders for contractor’s errors during the bidding process. Wiremold or surface mounted raceways in finished areas are not allowed, unless noted otherwise.

1.5 REFERENCES

A. IEC 61537 (2001) – Cable Tray Systems and Cable Ladder Systems for Cable Management

B. NEMA VE 1-2002/CSA C22.2 No. 126.1-02 – Metal Cable Tray Systems

C. ANSI/NFPA 70 (2005) – National Electrical Code (NEC)

D. TIA 569-A (1998) and addendums – Commercial Building Standard for Telecommunications Pathways & Spaces

E. ASTM A 510 - Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

F. ASTM A 380 – Specification for Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

G. ASTM B 633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel

H. ASTM A 123 – Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

I. ASTM A 653 - Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality

J. Norm NF/A 91-131 for Galvanized Steel

K. Norm NF/EN 12-329 for Electrozinc Coating

L. Norm NF/EN/ISO 14-61 for Hot-Dipped Galvanized Steel

M. Norm NF 10-088-2 for Stainless Steel

1.6 SYSTEM DESCRIPTION

A. This section outlines the performance for the noted cable tray support systems, as indicated on the telecommunication drawings. The cable tray system shall provide a common raceway for telecommunications cable into and out of the MDF and IDF rooms. Cable tray systems shall also be installed above finished ceiling in the common areas that are located on all floors of the building. The common area cable tray is intended to support telecommunications cabling from any of the station cable wall/floor outlet locations on any floor. Each station cable wall/floor outlet shall have a configuration of conduit/pipe run to the tray system to support the aforementioned station cabling. It is intended to have this tray system transition (via a Cable Dropout or Runway Radius Drop) into the ladder tray installed above the noted equipment racks to be located in the MDF and IDF rooms.

1.7 DESIGN REQUIREMENTS

A. Maximum Deflection between Supports: L/240.

1.8 SUBMITTALS

A. Comply with requirements of Section 01 33 00 - Submittal Procedures.

B. Submittal data is to be submitted in a three ring binder, a continuous spiral binder, or plastic binding that allows the booklet to lie flat while open. Each booklet shall contain the below in the following order:
   1. Cover Sheet.
      a. Include name of supplying contractor and project name.
   2. Detailed Bill of Materials.
      a. Include a listing of: component quantities, equipment manufacturer, model number, and description of each component being supplied, and the specification paragraph or drawing sheet that corresponds to the product. Failure to provide this information will result in the rejection of submittals.
   3. Product Data.
      a. Include a catalog sheet per product of equipment listed in the Detailed Bill of Materials, in the exact order as the Detailed Bill of Materials. Each catalog sheet shall describe mechanical, electrical and functional equipment specifications. The catalog sheet must also include a image of the product. Photocopy duplications of the manufacturer's original equipment catalog sheets

will be allowed as long as they provide adequate clarity of both the printed word and graphics/pictures. If more than one product is shown on the catalog sheet the intended product must be denoted by either an arrow or highlight.

4. Prequalification Certificate.
   a. Copy of the installing technician(s) certificate of completion from the manufacturer's training school for the equipment being provided.
5. Manufacturer Qualifications
   a. Submit manufacturer's certification indicating ISO 9002 quality certified.
6. Design Calculations
   a. Verify loading capacities for supports.
7. Submit Factory-certified test reports of specified products, complying with IEC 61537, NEC, and NEMA VE 1/CSA C22.2 No. 126.1.

C. Shop Drawings are to be submitted on project standard full size and bound. Each shop drawing set is to include the below in the following order:
   1. Title Sheet.
      a. Containing, at a minimum, a list of all drawings in the set and a symbols legend defining each symbol used in the package.

D. Coordination Drawings
   1. Include floor plans and sections drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural and mechanical elements. Data presented on these drawings are as accurate as preliminary surveys and planning can determine. Field verification of all dimensions, routing, etc., is directed.

E. Cable Tray Drawings
   1. Submit drawing indicating materials, finish, dimensions, and accessories. Show layout, support, and installation details.
      a. Include elevation drawings detailing elevations of the basket tray with respect to conduit, ductwork, and any equipment associated with other trades.
      b. Basket tray shall be accessible and located beneath all other trades.

1.9 CLOSEOUT SUBMITTALS

A. At the completion of the installation, but before Final Acceptance, provide for review and approval the following, in compliance with Division 1 Section *Closeout Procedures.*
   1. Operation and Maintenance Manuals:
      a. Equipment manufacturers operation and service manuals for each make and model of equipment.
      b. System Operation Manual. Produce a manual specifically for the subsystems detailed herein. The manual shall describe all procedures necessary to activate each system to provide for the functional requirements, except as specifically excluded by the Owner. This section shall provide a simple "How-to" users guide for the procedures needed to operate the systems.

1.10 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Manufacturer Qualifications: ISO 9002 quality certified.

C. Comply with NFPA 70. National Electrical Code, Article 392: Cable Trays; provide UL Classification and labels.

D. Provide ETL test documentation showing cable compression/deformation testing.

1.11 COORDINATION

A. Coordinate layout and installation of cable tray with other installations.
   1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the CO.

B. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store cable trays and accessories in original cartons and in clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage. Protect materials and finishes during handling and installation to prevent damage

C. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. One of the following below or approved equal.
   1. Cablofil
   2. B-Line/Cooper
   3. Cope/Atkore
   4. MPHusky
   5. Thomas & Betts
   6. Legrand

2.2 CABLE TRAY SYSTEM

A. Cable trays in MDF and IDF rooms shall be of the ladder type, black in color. Cable trays in public corridors shall be of the wire mesh type. Coordinate with NIST for the cable tray type that will be installed in the labs.

B. Description: Cablofil EZ Tray continuous, rigid, welded steel wire mesh cable tray system.
   1. Mesh System: Permits continuous ventilation of cables and maximum dissipation of heat.
   2. Safety Edge: Continuous safety edge T-welded wire lip.
   3. Wire Mesh: Welded at all intersections.

C. UL Classification: Straight sections 4 x 8, 12, and 18 inches (108 x 200, 300, and 450 mm), UL classified. Width of tray shall be determined based on not exceeding industry standards for fill ratios.

D. Material: Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.

E. Finish for Carbon Steel Wire: Finish applied after welding and bending of mesh.
   1. Electro-Plated Zinc Galvanizing: ASTM B 633, Type III, SC-1, or
   2. Hot-Dip Galvanizing: ASTM A 123, or
   3. Flat Black: Powder painted surface treatment using ASA 61 black polyester coating.

F. Nominal Dimensions:
   1. Mesh: 2 x 4 inches (50 x 100 mm).
   2. Straight Section Lengths: 80 inches (2,000 mm) and 118 inches (3,000 mm).
   3. Width: [2 inches (50 mm)], [4 inches (100 mm)], [6 inches (150 mm)], [8 inches (200 mm)], [12 inches (300 mm)], [18 inches (450 mm)], [24 inches (600 mm)].
   4. Depth: [4 inches (108 mm)].

5. Wire Diameter: 0.177 inch (4.5 mm), minimum.

G. Fittings: Field fabricated in accordance with manufacturer's instructions from straight sections.

H. Support System: Standard.
1. Wall Installation: CS Bracket. Maximum tray width of 12 inches (300 mm).
2. Trapeze Mounting to Ceilings: CS Profile. Maximum tray width of 18 inches (450 mm).
3. Ceiling Installation: CSC Bracket. Maximum tray width of 12 inches (300 mm).
4. Fasteners: As required by tray widths. Furnished by manufacturer.

I. Support System: Caloric FAS System.
1. Floor and Wall Installation: FAS Profile.
2. Wall Installation:
a. FAS Universal Bracket. Maximum tray width of 24 inches (600 mm).
b. FAS L Bracket. Maximum tray width of 12 inches (300 mm).
3. Ceiling Installation: FAS C Bracket. Maximum tray width of 12 inches (300 mm).
4. Fasteners: Not required.

J. Hardware: Hardware, including splice connectors and support components furnished by manufacturer.

2.3 ACCESSORIES

A. Shielding Divider Strips: Divider strips to follow contour of cable tray run for shielding to run power and control cables in same tray. Pre-galvanized steel, [4 x 1-1/2 inches (108 x 30 mm)].

B. Fittings: Tees, crosses, risers, elbows, radius tees, and other fittings as indicated, of the same materials and finishes as cable tray.

C. Grounding: GTA-2-2 grounding lugs for attachment on tray of continuous ground conductor fixing system.

2.4 FIRE STOP CABLE PASS-THRU SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are limited to, the following:
1. Basis of design: Specified Technologies Inc.
2. Approved equal by:
a. 3M Corporation.
b. Hilti Corporation.
c. Wiremold- Legrand Corporation.

B. Fire Rated Cable Pathways: STI EZ-PATH ™ Brand device modules comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:
1. Specified Technologies Inc. (STI) EZ-PATH Series 44 Fire Rated Pathway
2. Specified Technologies Inc. (STI) EZ-PATH Series 33 Fire Rated Pathway

PART 3 - EXECUTION

3.1 EXAMINATION

A. Exam areas to receive cable management system. Notify the CO of conditions that would adversely affect the installation or subsequent utilization of the system. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install cable tray level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Install cable management system at locations indicated on the drawings and in accordance with manufacturer's instructions. Install the cable tray system directly above the racks positioned within the space to allow for ease in cable management to and from the racks. Provide firestopping at penetration into/ out of Telecommunication rooms.

C. Load Span Criteria: Install and support cable management system in accordance with span load criteria of L/240.

D. Cutting:
   a. Cut cable tray wires in accordance with manufacturer's instructions.
   b. Cable tray wires must be cut with side-action bolt cutters with offset head to ensure integrity of protective galvanic layer.
   c. Remove burrs and sharp edges from cable trays.

E. Install cable management system using hardware, splice connectors, support components, and accessories furnished by manufacturer.

F. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed 90 feet.

G. Ground cable tray according to manufacturer's written instructions.

H. The cable tray and ceiling installation shall allow for re-entry to accommodate additional cable to be pulled from all occupied spaces to their respective IDF locations on each floor.

I. Provide bend limiters to maintain cable type bend radius whenever cable exists cable tray into MDF and IDF rooms.

J. Provide radius kits at all 90-degree turns.

K. Provide conduit connectors for all conduits intended to route cabling directly from devices to the basket tray.

L. Cable tray shall be supported via trapeze method.

M. Provide at least 3" clearance above cable tray for accessibility. Contractor shall provide conduits in areas where the 3" clearance cannot be achieved. Coordinate accessibility issues with NIST prior to cable tray installation.

N. Contractor shall provide the proper width of cable tray to accommodate the number if cables that will be installed in the cable tray.

O. Certified Installers: Cable tray installers must have successfully completed Cablofil's Certified Installer program.

3.3 FIRESTOPPING

A. Firestopping In MDF and IDF rooms At Cable Tray Entrance
   1. Install EZ Path Series 44 as shown on contract drawings.

B. Firestopping where cable tray passes through a rated wall assembly.

1. Install quantity of EZ Path series 33 or series 44 to 100% fill ratio of the size of cable tray at entrance to opening.

C. General: Install through-penetration firestop systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.

D. Manufacturer's Instructions: Comply with manufacturer's instructions for installation of firestopping products.

End of Section

SECTION 28 31 13

FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Division 1 Specification sections, apply to the work specified in this section.

1.2 RELATED SECTIONS

A. Section 26 00 10: Common Work Results For Electrical Systems

B. Section 26 05 19: Low Voltage Electrical Power Conductors and Cables

C. Section 26 05 26: Grounding and Bonding for Electrical Systems

D. Section 26 05 29: Hangers and Supports for Electrical Systems

E. Section 26 05 33: Raceways and Boxes for Electrical Systems

F. Section 26 05 53: Identification for Electrical Systems

G. Section 28 05 00: Common Work Results for Electronic Safety and Security

H. NIST Fire Protection & Life Safety for Design and Construction – NIST S 7401.01 (Current Version)

1.3 SUMMARY

A. This section of the specification includes the design, furnishing and installation of additions and revisions to an existing system so as to provide a complete and operational fire alarm system. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, Fire Alarm Control Panel (FACP), Fire Alarm Annunciator Panel (FAAP), auxiliary control devices, power supplies, and wiring as shown on the drawings and specified herein.

1.4 CONTRACTOR PERSONNEL QUALIFICATIONS

A. System designers and installers qualifications shall meet the Qualifications requirements of chapter 10 of NFPA 72.

B. In addition to meeting the personnel qualification requirements of chapter 10 of NFPA 72, Inspection, testing, and service personnel are required to be competent through training and experience for the specific type and brand of fire alarm system (Notifier®) installed at these locations. Inspection, testing, and service personnel are required to be employed by an organization that is authorized by the manufacturer (Notifier®) to inspect, test and service this specific type and brand of fire alarm system installed at these locations and an organization that is certified to work on dedicated fiber networked systems. Manufacturer requirements of equipment and intended use are critical to successful service and maintaining equipment warranties and guarantees.

1.5 SCOPE OF WORK

~~A. The addressable fire alarm system shall be designed and installed in accordance with the specifications and drawings. Provide a complete, addressable, microprocessor-based, networkable Notifier 3030 fire alarm~~

~~control panel with initiating devices, notification appliances, monitoring and control devices. The new fire alarm system shall be connected to the existing NIST fiber optic network.~~

~~B.~~A. The fire alarm equipment vendor shall be a representative of Notifier and NESCO.

C. Provide graphic maps for each fire alarm control panel at the NIST facility depicting the renovated building in its entirety. Match existing screen format and nomenclature. Provide disabled points as requested by NIST COR.

D. Circuits for the new system shall be as follows:
1. Initiation Device Circuits (IDC's) shall be wired Class A.
2. Signaling Line Circuits (SLC) shall be wired Class A.
3. Notification Appliance Circuits (NAC) shall be wired Class A.

1.5 SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 00.

B. Submit prior to ordering equipment:
1. Description of system operation.
2. Manufacturer's literature marked to show model and catalog number for all equipment.
3. Manufacturer's installation instructions and operations and maintenance instructions.
4. A complete set of shop drawings ~~with a layout of the entire system including wire sizes and types.~~
5. Battery sizing calculations indicating circuit loading and power supply loading.
6. Voltage drop calculations.

C. Certifications:
1. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.

D. Record Documents:
1. Completed set of record drawings with final voltage drop and battery calculations.
2. Complete system testing and record of completion documents per NFPA 72 before scheduling acceptance test. Include testing report in final Operations and Maintenance Manual.

1.6 WARRANTY

A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one year from the date of acceptance. The full cost of labor and materials required to correct any defect during this one-year period shall be included in the bid.

1.7 REFERENCE PUBLICATIONS

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only. All publications listed below refer to the most current edition.

A. National Fire Protection Association (NFPA):

NFPA 70 National Electric Code (NEC)
NFPA 72 National Fire Alarm Code

B. Underwriters Laboratories Inc. (UL) - USA:

No. 50 Cabinets and Boxes.
No. 464 Audible Signaling Appliances.

No. 1481 Power Supplies for Fire Protective Signaling Systems.
No. 1971 Visual Notification Appliances.

1.8 APPROVALS

A. The system must have proper listing and/or approval from the following nationally recognized agencies:

UL Underwriters Laboratories Inc

1.9 BUY AMERICAN ACT REQUIREMENTS

A. This contract is subject to the Buy American Act and as required by that Act, Work performed under this Contract shall use only domestically produced construction materials except when impossible due to documentable reasons.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIAL, GENERAL

A. Material and equipment shall be of standard products of a manufacturer regularly engaged in the manufacturing of fire alarm and security equipment. Equipment shall be supported by a service organization that can provide service within 4 hours of notification. Existing equipment may be re-used if properly protected during demolition phase.

B. All equipment and components shall be the manufacturer's current model, except as noted on the drawings. Match new devices with existing devices as required. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approval agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.

C. Provide Updated Graphic Zone Maps at FACP and remote FAAP.

D. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceiling). Fasteners and supports shall be adequate to support the required load

E. All equipment shall be clearly labeled with typewritten text (Brady Label) at a font size of at least 18 point.
~~Smoke detectors and manual pull stations shall be labeled with the device address on the base of the detector or manual pull station.~~
1. All notification appliances shall be labeled with the notification appliance circuit designation. The "end of line" shall be clearly labeled.
2. Monitor and relay modules shall be labeled with the device address and function.
~~The Fire Alarm Control Panel Node number shall be coordinated with the COTR and labeled~~.

2.2 CONDUIT AND WIRE

A. Conduit:
1. Conduit shall be no smaller than 3/4" red, hot-galvanized, fire alarm EMT. Paint boxes red.

B. Wire:
~~1.~~3. Wire shall be manufactured by Tappan or equivalent.
~~2.~~4. THHN shall be permitted in conduit for strobe, IDC or power circuits only. THHN shall be solid and shall be between 8 and 12 twists per foot and shall meet the requirements of UL and ASTM-B3, ASTM-B787 and ASTM-B8. The outer nylon jacket shall meet the requirements of UL-1063 and UL-83.

~~3.~~5. Wire runs may not be spliced. Pull continuous lengths from device terminal to device terminal in order to maintain the integrity of the electrically supervised system.

~~4.~~6. Any wiring shall be in accordance with national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for signaling line circuits and 16 AWG for notification appliance circuits.

5. Temporarily store at panel or above ceiling wiring that runs from the area of work to the fire alarm control panel so that it can be re-used for the relocation of devices in the Spine if suitable.
6. All new wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
7. All wiring shall be installed in red ¾" minimum conduit. Conduit fill shall no exceed 40 percent of interior cross sectional area where there or more cables are contained within a single conduit. Flex conduit is permitted for a single ceiling mounted device or a single wall mounted manual pull station.
8. T-Tapping of IDC or NAC is not acceptable.
9. It shall be the responsibility of the contractor to return all wires to the panel free of opens, grounds, shorts and/or any other condition that may prevent the proper operation of the fire alarm system.

C. Terminal Boxes, Junction Boxes and Cabinets:
1. All boxes and cabinets shall be UL listed for their use and purpose.
2. All boxes and cabinets shall be red.
3. Electrical junction boxes shall be covered with a red cover plate and sealed as required by the room NEMA rating.
4. Electrical back boxes shall utilize knockouts only as necessary. Unused knockout holes are not permitted.
5. All box knock outs and exposed conduit edges shall have plastic edge protection (RCR50 or equivalent).
6. Ceiling mounted junction boxes shall be secured with Caddy T-bar hangers Catalog #512HD.

~~D. The fire alarm control panel and any new power supplies shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold water pipe or grounding rod. Surge protection shall be provided for the fire alarm control panel. All breakers used for 120VAC power to the FACP or power supplies shall be locked (screw lock) and tagged.~~

~~2.3 FIRE ALARM CONTROL PANEL (FACP)~~

~~**A. General: Comply with UL 864, 9th edition, "Control Units for Fire-Protective Signaling Systems." Panel shall be Notifier 3030. The following FACP hardware shall be provided:**~~
~~**Power limited base panel with cabinet and door, 120 VAC input power.**~~
~~**Provide battery voltage and ammeter readouts from the LCD Display.**~~
~~Door shall be equipped with security contact.~~

~~Remote Unit Interface: supervised serial communication channel for control and monitoring of remotely located annunciators, transponders, and I/O panels.~~
~~Common Event DACT.~~
~~Cabinet: Lockable steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures.~~
~~Alphanumeric Display and System Controls: Panel shall include a minimum 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.~~
~~Distributed Module Operation: FACP shall be capable of allowing remote location of the following modules; interface of such modules shall be through a Style 6 Class A supervised serial communications channel (Addressable Signaling Line Circuit):~~
~~Initiating Device Circuits~~
~~Notification Appliance Circuits~~
~~Auxiliary Control Circuits~~

~~2.4 SMOKE DETECTOR~~

~~A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:~~
~~**Factory Nameplate: Serial number and type identification.**~~
~~**Operating Voltage: 24 VDC, nominal.**~~
~~**Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.**~~
~~**Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.**~~
~~**Each sensor base shall contain an LED that will flash each time it is scanned by the Control Unit (approximately once every 4 seconds). In alarm condition, the sensor base LED shall be on steady.**~~
~~**Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.**~~
~~**Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.**~~
~~**The sensor's electronics shall be immune from false alarms caused by EMI and RFI.**~~
~~**Addressability: Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP. Sensor address shall be located in base to eliminate false addressing when replacing sensors.**~~
~~**Removal of the sensor head for cleaning shall not require the re-setting of addresses.**~~
~~Type: Smoke sensors shall be Notifier IntelliQuad including these features~~
~~1. Electrochemical cell technology that monitors carbon monoxide (CO) produced by smoldering fires~~
~~2. Infrared (IR) sensing that measures ambient light levels and flame signatures~~
~~3. Photo-electric smoke detection~~
~~4. Thermal detection for temperature monitoring of the photoelectric type.~~

~~B. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:~~
~~1. Primary status.~~
~~2. Device type.~~
~~3. Present average value.~~
~~4. Present sensitivity selected.~~
~~5. Sensor range (normal, dirty, etc.).~~

~~C. Duct Smoke Sensor: Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Sensor includes relay as required for fan shutdown.~~

~~The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable.~~

~~Duct Housing shall provide a relay control trouble indicator Yellow LED.~~

~~Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.~~

~~Duct Housing shall provide two (2) test ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.~~

~~Duct Housing shall provide a magnetic test area and red sensor status LED.~~

~~For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.~~

~~Each duct sensor shall have a remote test station with an alarm LED and test switch.~~

2.5 ADDRESSABLE DRY CONTACT MONITOR MODULE

A. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panels SLCs.

B. The IDC zone shall be suitable for Class A operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational an in regular communication with the control panel.

2.6 ALARM NOTIFICATION APPLIANCES

A. Notification Appliances: The Contractor shall furnish and install speakers, speaker/strobes and strobes that match the site's existing appliances. Replace ~~A~~any existing notification appliances cannot be reused upon testing and inspection. Coordinate color of appliances and lens color with notification device purpose and NIST.

~~B. Speaker: Speaker shall be listed to UL 464. The speaker shall have a minimum sound pressure level of 80 dBA @ 24VDC. The tapped wattage of the speakers shall be adjustable between a minimum of ¼ watt and 2 watts. Speaker input shall be a dual-voltage transformer speaker strobe capable of operation at 25.0 or 70.7 nominal Vrms. The speaker shall mount directly to a standard single gang, double gang or 4" square electrical box, without the use of special adapter or trim rings.~~

~~**C. Visible/Only: Strobe shall be listed to UL 1971. The V/O shall consist of a xenon flash tube and associated lens/reflector system. The V/O enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot. V/O appliances shall be provided with different minimum flash intensities of 15cd, 75cd and 110cd. Provide a label inside the strobe lens to indicate the listed candela rating of the specific Visible/Only appliance.**~~

B. Audible/Visible: Combination Audible/Visible (A/V) Notification Appliances shall be listed to UL 1971 and UL 464. The strobe light shall consist of a xenon flash tube and associated lens/reflector system. Provide a label inside the strobe lens to indicate the listed candela rating of the specific strobe. The speaker shall have a minimum sound pressure level of 80 dBA @ 24VDC. The audible/visible enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. The visual appliances shall continue to operate after the audible notification appliances have been silenced. The visual notification appliances shall restore to normal when the fire alarm control panel is reset.

2.6 EMERGENCY PUSH BUTTON STATIONS

A. Push Button Stations: The contractor shall furnish and install push button stations that match the site's existing Hood EPO buttons. – Button shall be equipped with "Turn to reset feature". Replace any existing notification appliances cannot be reused upon testing and inspection.

B. EPO Contact block: Rated operational characteristics conforming to EC/EN 60947-5-1. Provide with screw clamp terminals.
1. AC Supply utilization category AC-15. Ue = 600VAC and Ie = 1.2A with continuous Thermal current rating of 10A
2. DC supply characteristics utilization category DC-13. Ue = 24VDC and Ie = .5A
3. Confirm N.O/N.C. operational requirements with NIST personnel.

~~2.7 PULL STATIONS~~
~~**A. Description: Addressable double-action type, red LEXAN or metal, and finished in red with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.**~~

~~2.8 BATTERIES AND EXTERNAL CHARGER~~

~~A. Battery:~~
~~1. Shall be a 12 volt, Gel-Cell type.~~
~~2. Battery shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus fifteen minutes of alarm following a normal AC power failure.~~
~~3. The batteries are to be completely maintenance free. No liquids, fluid level checks, refilling, shall be required. No spills and leakage shall be possible under normal operating conditions.~~

~~B. System Battery Charger:~~
~~1. Shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120/240-volt 50/60 hertz source.~~
~~2. Shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.~~
~~3. Shall have protection to prevent discharge through the charger.~~
~~4. Shall have protection for overloads and short circuits on both AC and DC sides.~~

PART 3 - EXECUTION

3.1 DESIGN

A. The system design submittal shall be stamped by a licensed Fire Protection Engineer, registered in CO.

3.2 INSTALLATION

A. Temporarily re-route wiring and protect existing equipment during construction operations to maintain system operability.

B. Installation shall be in accordance with the NEC and NFPA 72, as shown on the drawings, and as recommended by the major equipment manufacturer.

C. Installation shall be by a NICET II certified Fire Alarms Technician or other qualifications as allowed under NFPA 72 guidelines. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes.

D. All junction boxes and hangers shall be concealed in finished areas and only conduit may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.

~~E. All fire detection and alarm system devices, control panels and remote annunciators shall be located in areas acceptable to the Government Authority Having Jurisdiction.~~

~~F.~~E. All equipment and components shall be installed in strict compliance with manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.

~~G.~~F. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

~~H.~~G. Coordinate with all construction and consultants on locations of duct detectors and fire/smoke dampers.

~~I. If detected, finished areas shall be equipped with photoelectric detectors and heat detectors shall be used in mechanical and electrical rooms.~~

~~J. Each telecomm rooms shall also be protected with a photoelectric detector(s).~~

~~K. Provide necessary connections, programming, hardware for fire pump, pre-action system, VESDA, etc.~~

~~L. Contractor shall install new fiber optic cables as required to connect the new FACP to NIST's existing fire alarm network. Coordinate exact cable and connector types with NIST prior to submitting product data/shop drawings.~~

~~M.~~H. Contractor shall update the NIST fire alarm system programming to accommodate the new devices added in this renovation project.

~~N.~~I. If fume hoods are installed, provide fume hood panic alarms. Install panic button on the fume hood and an amber horn-strobe in the public corridor adjacent to the lab door. These devices shall be tied into the fire alarm system and programmed as latching medical response alarms. Provide all modules, wiring, etc. for a complete and operational system. Coordinate exact device model numbers and labeling requirements with NIST.

~~O. Provide the proper amount of speakers for mass notification message legibility per NFPA.~~

~~P.~~J. Install address labels on all initiating devices.

~~Q. The FACP door shall be wired and alarmed so that alerts the system when the door is open.~~

~~R. When installing notification devices in labs, the devices shall be installed as high as code allows to ensure they are not obstructed by laser curtains, etc. Additional devices may need to be installed depending on the obstruction(s).~~

~~S.~~K. The layout of notification devices shall meet NFPA 72 intelligibility requirements.

3.3 SYSTEM OPERATION

A. Actuation of any manual station, smoke detector, or flow switch shall cause the following operations to occur unless otherwise specified:
   1. Activate all programmed notification circuits until silenced.
   2. Actuate all strobe units until the panel is reset.
   3. Annunciate the active initiating devices on the FACP and Remote Annunciator.
   4. Transmit the alarm condition to designated locations.

B. Actuation of a trouble condition; open circuit, short circuit, internal malfunction, loss of equipment, etc. shall cause the following operations to occur unless otherwise specified:
   1. Annunciate the active trouble devices and zones on the FACP.
   2. Transmit the trouble condition to remote annunciators.

C. Actuation of a tamper switch or other supervisory condition shall cause the following operations to occur unless otherwise specified:
   1. Annunciate the active supervisory devices and zones on the FACP.
   2. Transmit the supervisory condition to designated locations.

3.4 TEST

A. Provide the service of a competent, factory-trained representative authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.

B. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, and continuity.

C. Open initiating device circuits and verify that the trouble signal actuates.

D. Open signaling line circuits and verify that the trouble signal actuates.

E. Open and short notification appliance circuits and verify that trouble signal actuates.

F. Ground initiating device circuits and verify response of trouble signals.

G. Ground signaling line circuits and verify response of trouble signals.

H. Ground notification appliance circuits and verify response of trouble signals.

I. Check presence and audibility of tone at all alarm notification devices.

~~J. Check installation, supervision, and operation of all smoke detectors.~~

K. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.

L. When the system is equipped with optional features, the manufacturer's manual should be consulted to determine the proper testing procedures.

M. Preliminary NFPA 72 Test and Inspection and Record of Completion documents and as-builts shall be presented before the final inspection for the Government to verify the validity of the system installation, testing and as-builts, including and not limited to the placement of devices, circuits and measured voltage drops of all the NAC circuits.

N. Contractor shall perform their own pre-functional testing to confirm system works properly before the final acceptance test with NIST is scheduled.

3.5 FINAL ACCEPTANCE TEST/INSPECTION

A. At the final inspection a factory-trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.

B. Contractor shall schedule the final acceptance test, for NIST to witness, prior to Substantial Completion. The system shall be tied into the site's existing fire alarm network when the final acceptance test is per-

formed. All punch list items derived from the final acceptance test shall be addressed and corrected prior to Substantial Completion.

C. The record NFPA 72 Test and Inspection and Record of Completion shall be presented at the final inspection.

D. Record drawings shall be presented for the final inspection acceptance and approved by NIST prior to Substantial Completion.

3.6 ~~INSTRUCTION~~

~~A. The contractor and/or the systems manufacturer's representatives shall provide a typewritten "Sequence of Operation" and shall post a copy on the interior of the FACP.~~

~~3.7 TRAINING~~

~~A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.~~

~~1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum one (1) 4 hour training.~~

~~2. Schedule training with the Owner at least fourteen days in advance.~~

END OF SECTION 283113

NIST – Color Chart

Conduit Color Chart	Label Color Chart	Wiring Device Color
Normal Power Branch – Grey	Grey w/ white letters	Grey
Emergency Life Safety Branch – Yellow	Yellow w/ black letters	Yellow
Normal Power Research Branch – White	White w/ black letters	White
UPS/Generator Research Branch – Black	Black w/ white letters	Black
Emergency Telecomm Branch – Orange	Brown w/ white letters	Orange
Emergency Equipment Branch – Green	Green w/ white letters	Green
Mechanical Controls – Blue	Blue w/ white letters	Blue
Fire Alarm/VESDA - Red	Red w/ white letters	Red
Security – Purple	Purple w/ white letters	n/a

Note: “Branch” means entire path from main switchboard down to branch circuit device.

Electrical Naming Convention – rev4

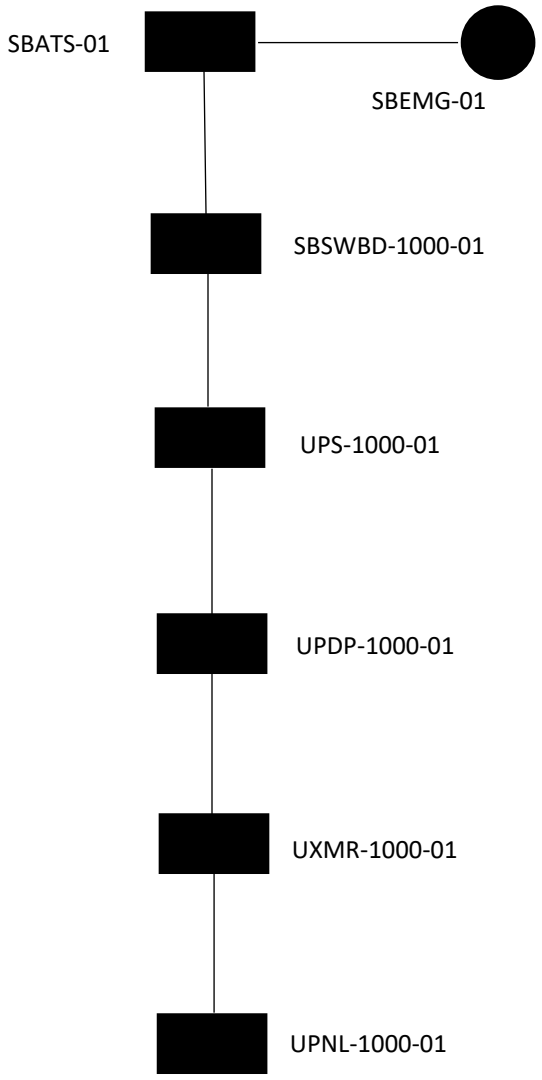
Equipment	Maximo ID	Label
Switchgear	B##-SWGR-####-##	SWGR-##-####
Switchboard	B##-SWBD-####-##	SWBD-####-##
Motor Control Center	B##-MCC-####-##	MCC-####-##
Power Distribution Panel (e.g. I-Line or Pow-R-Line 4B styles)	B##-PDP-####-##	PDP-####-##
Branch Distribution Panel	B##-PNL-####-##	PNL-####-##
Transformer	B##-XMR-####-##(#)	XMR-####-##(#)
	The third digit in the second grouping is meant for service entrance transformers only, e.g. XMR-001.	
Bus Duct	B##-BD-####-##	BD-####-##
Feeder Bus	B##-FB-####-##	FB-####-##
VFDs	B##-VFD-####-##	VFD-####-##
UPS	B##-UPS-####-##	UPS-####-##
Generator	B##-EMG-####-##	EMG-####-##
Automatic Transfer Switch	B##-ATS-####-##	ATS-####-##
Disconnect (CB or fused switch)	B##-DS-####-##	DS-####-##
Network Protector	B##-NP-####-##	NP-####-##
	The last "##" digits refer to the transformer #, from which the NP is fed. For example: NP-073 is the network protector fed from XMR-073. If the NP is in a room, e.g. NP-1065-001.	
Pad Mounted Switch	BOULDER-PMS-##-##	PMS-##-##
	Named w/ associated man-hole. E.g. PMS-15-01 would be pad mount switch on man hole 15, switch #1, or PMS-1A-01 is pad mount switch on mand hole 1A, switch #1.	
Air Switch	B##-AS-####-##	AS-####-##
High Speed Switch	BOULDER-HSS-##	HSS-##
Man Hole	BOULDER-MH-##	MH-##

B## - Denotes Building number numeric. #### - Denotes room/column line. ##- Denotes numeric (in some cases, this could denote a numeric/alpha character, e.g. MH-1A).

Notes:

- Use a numeric to identify equipment, e.g. SWGR-####-**01**, XMR-####-**05**, etc.
- Two general naming conventions for indoor or outdoor equipment:
  - Indoor equipment shall have an additional identifier added to the middle of the equipment name, designating the room where the equipment is installed, e.g. SWGR-**2K111**-01.
    - If the equipment is installed in a hallway, corridor (with no hallway or corr #) or non-descript room, utilize the nearest column designations, e.g. PNL-**A15**-01.
  - Primary voltage rated outdoor equipment (13.2kV) will have no identifier after its numeric name, e.g. HSS-**01**.

    - Outdoor equipment rated at utilization voltage levels (600V and below) will be identified by the designator “B##X”. For example, a 15 kVA dry type transformer, located outside of B02 would be designated as XMR-**02X**-01.
- Recommend adding an “SB” for emergency or standby power in front of a given equipment identifier. For example: **SB**SWGR-1800-01, **SB**PDP-1800-01, **SB**ATS-01, etc.
- For life safety, utilize “LS”, e.g. **LS**PNL-1000-01, **LS**ATS-1000-01, etc.
- Utilize a “M” designator for mechanical loads.
- Utilize “IT” for IT designated loads.
- Utilize “U” for UPS loads.
- Distinction shall be made for those systems that are on standby power and have a stationary UPS system. For example:



Those items including the generator, ATS, downstream equipment off of the ATS but before a UPS, shall use “SB” designators.
Those items downstream of the UPS shall have “U” designators.
If there was no UPS in the system, the system naming would comprise of all “SB” designators.

- An example of a full Maximo technical ID would be: 01-SBSWGR-1000-01, 01C-SWGR-1000-01, 02-PDP-1000-01. Even if room #'s duplicate between buildings which could possibly result in duplicate equipment names, Maximo will have unique identifiers, as the building # is a part of the Maximo asset name.
- Outdoor equipment which services a given building, will still receive a building numeric in its Maximo technical ID, e.g. 12-XMR-052 is the outdoor, padmount transformer that serves Bldg. 12.
- With regards to feeder bus and bus duct naming. The name of the run will be dependent on where the feeder/bus duct receives its electrical feed. For example, if the bus duct, cable tap box is installed in room 1000, then the asset name would be: BD-1000-01, regardless if the entire run spans a number of rooms or floors.
- Not all Equipment entered into Maximo will receive a job plan.
- We will have to be diligent about maintaining unique numeric names for outside/indoor service entrance transformers. Since the site MV one line has all of the service entrance transformers on the drawing, it could get confusing if there were duplicate names on one drawing.
- "BOULDER" is used in the Maximo asset name to identify outdoor equipment that does not service one area. Pad mount switches, man holes and high-speed switches will use this descriptor.
- Use no more than two designators for a given piece of equipment. For example, a mechanical panel on standby could be identified as SBMPDP-1000-01 beginning with the upstream electrical system and then finally the connected load. UITPNL-1000-01 would be used for IT equipment on the standby generator/UPS system.
- Main-Tie-Main switchgear configurations shall be named as -01 & -02. For example: SWGR-2000-01 & SWGR-2000-02. For those switchgear configurations that have no tie, but have dual mains, only use one designator, e.g. SWGR-3000-01.

UPDP-1000-01

480/277V, 3ph, 4W, 600A

Fed from UPS-1000-01

Example of a power distribution panel (for a lab area) on UPS.

PNL-1000-01

208/120V, 3ph, 4W, 100A

Fed from XMR-1000-01

Example of a branch circuit panelboard on “house” power.

- Label standard: 5”H x 7”L, phenolic style labels. Colors as indicated below:

Conduit Color Chart	Label Color Chart	Wiring Device Color
Normal Power Branch – Grey	Grey w/ white letters	Grey
Emergency Life Safety Branch – Yellow	Yellow w/ black letters	Yellow
Normal Power Research Branch – White	White w/ black letters	White
UPS/Generator Research Branch – Black	Black w/ white letters	Black
Emergency Telecomm Branch – **Orange**	Brown w/ white letters	Orange
Emergency Equipment Branch – Green	Green w/ white letters	Green
Mechanical Controls – Blue	Blue w/ white letters	Blue
Fire Alarm/VESDA - Red	Red w/ white letters	Red
Security – Purple	Purple w/ white letters	n/a

- A 3”H x 5”L label is acceptable for smaller load center, branch circuit panelboards.

ELECTRICAL ENGINEERING

1. LIGHTING PERFORMANCE REQUIREMENTS
2. LIGHTING PERFORMANCE ATTRIBUTES
   - 2.1. LIGHTING QUALITY
   - 2.2. LIGHTING QUANTITY
   - 2.3. ENERGY USE
   - 2.4. POWER QUALITY
   - 2.5. SERVICE LIFE
3. LIGHTING PRESCRIPTIVE REQUIREMENTS
   - 3.1. INDOOR LIGHTING AND DAYLIGHTING CRITERIA
   - 3.2. LOAD CRITERIA
   - 3.3. SECURITY LIGHTING, EXIT SIGNS, AND EMERGENCY LIGHTING
   - 3.4. SPECIFIC LIGHTING REQUIREMENTS
4. ELECTRICAL PERFORMANCE REQUIREMENT
5. PRESCRIPTIVE ELECTRICAL ENGINEERING REQUIREMENTS
   - 5.1. CODES, STANDARDS, AND GUIDELINES
   - 5.2. UTILITY COORDINATION
   - 5.3. SPACE CONDITIONS
   - 5.4. ELECTRICAL DISTRIBUTION SYSTEM
   - 5.5. SECONDARY BRANCH POWER DISTRIBUTION
   - 5.6. BRANCH WIRING DISTRIBUTION SYSTEMS
   - 5.7. EMERGENCY AND STANDBY POWER SYSTEMS
   - 5.8. UNINTERRUPTABLE POWER SYSTEMS
   - 5.9. GROUNDING SYSTEMS
   - 5.10. SOLAR PHOTOVOLTAIC SYSTEMS
   - 5.11. VOICE AND DATA DISTRIBUTION SYSTEM
   - 5.12. SAFETY SYSTEMS, EQUIPMENT, AND PERSONAL PROTECTION
   - 5.13. ALTERATIONS IN EXISTING BUILDINGS AND HISTORIC STRUCTURES
   - 5.14. ELECTRICAL SYSTEM STUDIES
   - 5.15. QUALITY ASSURANCE OF ELECTRICAL POWER SYSTEMS AND EQUIPMENT
6. Appendix A – Lighting Metrics/Measurements
7. Appendix B – Power Metrics/Measurements
8. Supplement #1 – NIST Conduit and Lable Color Chart
9. Supplement #2 – Electrical Equipment Naming and Labeling Conventions
10. Supplement #3 – Certificate of Occupancy Requirements

1. Lighting Performance Attributes

The following attributes make up a lighting system for any space. The descriptions below do not isolate electric lighting from daylighting.

Instead, the attributes apply to both sources of light and continually interact throughout the day to provide adequate and appropriate visibility.

1.1. Lighting Quality

Baseline: Does not have any requirements for vertical surface illuminance or color appearance, allows for CCT up to 4100K and minimum CRI of 80. Minimum illuminance uniformity ratio shall be 40:1. The baseline also has no minimal requirements for task lighting, glare control, and access to views.

Tier 1 High Performance (★): This level requires maximum illuminance uniformity ratios of 20:1 , Tunable CCT ambient overhead lighting between the ranges of 3000 to 6200K shall be provided for a more natural lighting environment and help coincide with the human circadian functions, and CRI of at least 80. It also requires task lighting, direct/indirect ambient lighting, view-preserving blinds, and views for at least 50 percent of regularly occupied areas.

Tier 2 High Performance (★★): Raises uniformity ratios to 10:1 and CRI to 90.

The R9 value shall have a minimum value of 50 with tunable CCT ranges of 3000 to 6200K. Occupants should have personal control over their entire work area or task lighting and access to views is increased to 80% of regularly occupied area.

Tier 3 High Performance (★★★): This performance level continues Tier 2 High Performance (★★).

1.2. Lighting Quantity

Recommended values of illuminance can be found in the Illuminating Engineering Society (IES) Standard.

Baseline: Meets the IES 10th Edition Handbook recommendations for horizontal illuminance and meets minimum average base surface reflectance recommendations of 80% for ceilings, 50% for walls, and 20% for floors.

Tier 1 High Performance (★): Meets the IES 10th Edition Handbook recommendations for both horizontal and vertical illuminance. Surface reflectances are increased to 90%/60%/20%. Daylight provides adequate lighting for 50% of the daytime occupancy and the electric lighting system is made up of 80% ambient and 20% task (+/- 10%).

Tier 2 High Performance (★★): This level maintains Tier 1 High Performance (★) but also allows for adjustable illuminance levels and recommends 90%/70%/25% minimum base surface reflectance. Additionally, daylight now provides for 80% of the daytime requirements and layers are divided 70% ambient and 30% task (+/- 10%).

Tier 3 High Performance (★★★): This level maintains Tier 2 High Performance (★★), but increases daylight autonomy to 100%, and splits electric light between 60% ambient and 40% task (+/- 10%).

Daylight autonomy refers to the percentage of annual daytime hours that daylight alone provides the required illuminance levels in regularly occupied spaces.

1.3. Energy Use

- Baseline: Exceeds ASHRAE 90.1 by 30% for Lighting Power Density (LPD) values.
- Tier 1 High Performance (★): This level exceeds ASHRAE by 40% for LPD values. Additionally, daylight, occupancy, and personal controls are required in all occupied spaces.
- Tier 2 High Performance (★★): Exceeds ASHRAE by 50% for LPD values. Addressable lighting control systems are required at this level in additional to personal control. Lighting control system shall be capable and employ energy monitoring of the lighting system.
- Tier 3 High Performance (★★★): Exceeds ASHRAE by 60% for LPD values. At this level, tunable CCT, addressable and personal controls are required along with real time energy monitoring and feedback features.

1.4. Power Quality

Baseline: All circuits must run separate neutrals. The overall electrical system must have a power factor (PF) of at least 0.90 and have a Total Harmonic Distortion (THD) less than 20% at the driver. Fully dimmed power factor and Total Harmonic Distortion are controlled to prevent damage to other building electrical components.

Tier 1 High Performance (★): Continues all of the Baseline criteria but lowers the THD limit to 15%.

Tier 2 High Performance (★★): Continues all of the Baseline criteria but lowers THD to 10%.

Tier 3 High Performance (★★★): This level maintains Tier 2 High Performance (★★) but lowers THD to 5% and increased power factor to .95.

1.5. Service Life

The serviceable life of the lighting system may not be as long as the actual life of all of its individual components. Space uses change.

Retrofits may make sense for improved energy savings. Renovations may require changes in lighting locations. The replacement of luminaires and sources might make sense in some cases.

Baseline: Lighting equipment should be expected to be replaced within 15 years.

Tier 1 High Performance (★): At this level, improved lighting equipment should not need replacement within 15 years as technological advances such as Solid state Lighting efficacy continues to advance, additional retrofitting maybe desirable.

Tier 2 High Performance (★★): Replacement and retrofit levels increase to 20 years.

Tier 3 High Performance (★★★): Replacement and retrofit levels increase to 20 years.

2. Lighting Prescriptive Requirements

2.1. Indoor Lighting and Daylighting Criteria

2.1.1. Qualifications of the Lighting Practitioner

Lighting design for new construction, lighting renovations, and energy retrofits must be performed or supervised by a lighting practitioner with a minimum of 10 years full- time experience in lighting design with at least two of the three following qualifications of LC, IES member, or IALD member, and who devotes the majority of his/her professional time to the design of architectural lighting.

2.1.2. Artwork

Solid State Lighting is the preferred light source for highlighting artwork, fabrics, and historical artifacts due to the absence of light IR energy spectrum that is detrimental to their preservation. Additional museum standards for lighting works of art must follow the IES 10th Edition Handbook; see Chapter 4.1, Installation Standards, in Fine Arts Collection Policies and Procedures 2007 for additional information.

2.2. Exterior Lighting Design Criteria

Exterior lighting must meet the IES 10th Edition Handbook recommendations and comply with the IDA/IES Model Lighting Ordinance (MLO) for lumen density limits and backlight, up-light, and glare (BUG) ratings or light pollution and light trespass performance method.

All Federal facilities shall be designed to the RP-8 Standard for "Enhanced Security Lighting."

Exterior luminaries and control systems must comply with all local zoning laws, and lighting levels for exterior spaces shall not exceed the IES 10th Edition Lighting Handbook recommendations.

Luminaires with instant strike light sources at all entrances and exits must be connected to the emergency lighting system.

2.2.1. Site Lighting

Illumination of exterior exit discharges must be in accordance with the requirements in NFPA 101 and IBC 2018

2.2.2. Open Parking Lots and Roadway Lighting

Parking lots and roadway lighting must be designed per RP-8 and RP-20 in addition to the IES and IDA/IES MLO requirements.

2.2.3. Parking Structures

Parking structure lighting must be designed per RP-20. Meet ASHRAE 90.1 requirements for controls related to parking garage luminaires. Luminaires must meet the following standards:

- Efficacy of a minimum of 85 lumens per watt (LPW)
- Wet-location & NEMA 4X rated
- Withstand mechanical vibration
- Life of minimum 50,000 operating hours for solid state lightings before reaching the L_{70} lumen depreciation per IES standard TM-21

- Lumen depreciation per IES standard LM-79
- Luminaire classification per IES TM-15

2.3. Illumination of Means of Egress

Illumination of means of egress shall be provided in accordance with the requirements in NFPA101. In addition, the use of automatic, motion sensor-type lighting switches shall be permitted within the means of egress, provided that the lighting control devices comply with the requirements in NFPA 101.

Exit Stair Illumination Enclosed stairway lighting shall be dimmed to at least 50 percent during periods of inactivity with brightness automatically raised upon detecting occupancy.

2.3.1. Emergency Lighting Criteria

Power loss resulting from utility system interruptions, building electrical distribution system failure, or the accidental opening of switches or circuit breakers dictates the requirement for emergency lighting.

2.3.2. Luminaires

Emergency electric lighting systems may consist of separate luminaries and wiring with an independent power source, e.g., a diesel generator, or separate luminaries or unit devices supplied by the normal power supply and a secondary source that comes on automatically when the normal power supply fails.

2.3.3. Emergency Lighting

Emergency lighting for means of egress must be provided in accordance with the requirements in NFPA 101 and tenant mission requirements.

Emergency lighting outside the building must also provide illumination to either a public way or a safe distance away from the building, whichever is closest to the building being evacuated.

2.3.4. Performance of Emergency Lighting System

The performance of the emergency lighting system must be in accordance with the requirements in NFPA 101.

2.4. Load Criteria

2.4.1. Lighting Loads

The lighting and daylighting systems must use 30 percent less electrical energy (kwh) than required for compliance with Section 9.6 (Alternative Compliance Path: Space- by-Space Method) of ASHRAE Standard 90.1.

General lighting must comply with the following luminaire, lamp, and driver requirements.

2.4.2. Solid State Luminaires and Retrofit Kits

All new solid-state luminaires must be high efficiency Design Lighting Consortium (DLC) PREMIUM. All luminaires must be appropriately selected based upon the expected application and be provided with replaceable dimmable drivers.

Where parabolic luminaires are used, louvers must be semi-specular or diffuse finishes; specular finishes must not be used.

LED lamps must not be retrofitted into existing luminaires unless the retrofitted product meets all of the following requirements:

LED retrofit kits may be used in existing luminaire housings if the photometric output is similar to the original fixture and meets the following requirements:

- UL rating is maintained for ENTIRE fixture to include UL 1598C and UL 1993.
- LED retrofits kits must be Design Lighting Consortium (DLC), Premium and be published on their Qualified Products website.
- Retrofitted lamps must be tested by a recognized Testing Laboratory in accordance with IES standards LM-79.
- Product MUST BE dimmable using 0-10V and compatible with existing lighting control systems and future daylighting technologies.
- LED products must have a "low risk" level of flicker (light modulation) of less than 5%, especially below 90Hz operation, to prevent photosensitivity-epileptic seizures as defined by IEEE standard 1789-2015LED.
- Space photometrics and glare control must meet IES guidelines for tasks performed in the retrofitted spaces.
- A mockup retrofit of typical areas of the building is required to confirm the above performance requirements of lighting output suitability controllability and flicker measurements.

Minimize lamps, light sources, and driver types.

2.4.3. Lamps

Effort must be made to minimize the number of fixture and lamp types within a facility to simplify lamp maintenance.

In retrofit scenarios, all fluorescent lamps must be recycled by firms that recover the mercury that is contained within the lamps. All applicable lamps must be FEMP compliant and/or ENERGY STAR certified as applicable.

2.4.4. Driver Acoustics

Electronic Drivers must be used wherever possible and have a sound rating of "A." All PCB-containing ballasts must be disposed of through specialized disposal firms that destroy the PCBs.

2.4.5. Lighting Controls

Control systems must be compatible with lamps, light sources, and drivers. Lighting controls must use individual luminaire control. Ambient lighting must be adjusted per daylight availability, occupancy/vacancy, and other BAS signals such as demand response.

Controls shall be provided in accordance with ASHRAE-90.1 or Task or personalized ambient lighting must be adjusted per occupancy/vacancy and personal dimming.

Lighting controls must be commissioned to operate as intended without false triggering. All lighting controls must be compatible with luminaires. Lighting control devices provided for illumination within exit enclosures must comply with the requirements in NFPA 101. Please see the Building Technology Technical Reference Guide for details on IT Security requirements.

2.5. Security Lighting, Exit Signs and Emergency Lighting

2.5.1. Security Lighting

Security lighting is lighting that remains on during unoccupied hours. Security lighting in daylit spaces must be controlled by photosensors. When security lighting also functions as emergency lighting, separate circuits and emergency ballasts are required.

2.5.2. Exit Signs

Exit signs must meet the requirements in NFPA 101 and be energy efficient and environmentally friendly products (e.g., light emitting diodes (LED type), photoluminescent type. Exit signs shall have red letters and chevrons. Tritium exit signs must not be installed.

2.5.3. Emergency Lighting

Emergency lighting must be provided in accordance with the requirements of NFPA 101. At a minimum, unswitched emergency lighting must be provided in the following areas:

- Zones covered by closed-circuit TV cameras
- Security zones
- Fire command center
- Security control center
- Where required in NFPA 101
- UPS and battery rooms

Emergency lighting may be manually switched from within in the following areas:

- Communication equipment rooms
- Electrical rooms
- Technology/server rooms
- Engineers' offices

- All lighting in the following rooms shall be on emergency power: Generator rooms
- Main mechanical and electrical rooms
- Any locations where lighting cannot be interrupted for any length of time

2.6. Special Lighting Requirements

2.6.1. Special Areas

Areas generally requiring special lighting treatment are as follows:

- Main entrance lobbies
- Atriums
- Elevator lobbies
- Public corridors
- Public areas
- Auditoriums
- Conference rooms
- Training rooms
- Dining areas and serveries

- Libraries

2.6.2. Lighting – Historic Buildings

Historic chandeliers, pendant lights, sconces, and other period lighting may be upgraded with energy efficient light sources and optical enhancements that preserve the historic appearance of the luminaire and space. Replica lighting for restoration zones should be fabricated or modified to accept energy efficient lamps. Supplemental lighting, when required, must be designed and located to minimize penetration of ornamental wall and ceiling surfaces and to avoid competing visually with historic lighting. Recommended alternatives for increasing light levels in ceremonial spaces, when relamping is insufficient, include compatibly designed floor lamps, task lights, and discretely placed indirect lighting.

3. Prescriptive Electrical Engineering Requirements

3.1. Design Intent

3.1.1. Electrical power, lighting, and communications systems must be specifically designed to meet all of the defined performance objectives of the project at full-load and part-load conditions that are associated with the projected occupancies and modes of operation. Commissioning of major changes to electrical power, lighting, and communications systems must be initiated at the conceptual design phase of the project and continue through all design and construction phases. Codes, Standards and Guidelines

Refer to Chapter 1 for guidance on code compliance.

3.1.2. Electrical Design Publications and Standards

The latest editions of publications and standards listed here are intended as guidelines for design. They are mandatory only where referenced as such in the text of this chapter or in applicable codes. The list is not meant to restrict or preclude the use of additional guides or standards.

When publications and standards are referenced as mandatory, any recommended practices or features must be considered as “required.” When discrepancies between requirements are encountered, NIST will determine the governing requirement. The following Codes and Standards requirements must be incorporated into any NIST project design. Refer to NIST Electrical Site Standard Specifications for additional codes and standards.

Codes and Standards

ANSI/NETA ATS, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

ANSI/NETA ECS, Standard for Electrical Commissioning Specifications for Electrical Power Equipment and Systems

ANSI/NETA ETT, Standard for Certification of Electrical Testing Technicians

ANSI/NETA MTS, Maintenance Testing Specifications for Electrical Power Equipment and Systems

ASME: American Society of Mechanical Engineers

ASME A17.1, Safety Code for Elevators and Escalators

ASTM: American Society for Testing and Materials

ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings

BICSI, (Building Industry Consulting Service International) Telecommunications Distribution Methods Manual

BICSI, Wireless Design Reference Manual

California Energy Commission, Building Energy Efficiency Standards (Title 24) for applicable projects

ETL: Electrical Testing Laboratories

FAA: Federal Aviation Agency

Federal Information Processing Standard 175, Federal Building Standard for Telecommunication Pathways and Spaces

IBC 2018, International Building Code

IECC 2018, International Energy Conservation Code

IEEE Standard 1789, IEEE Recommended Practices for Modulating Current in High- Brightness LEDs for Mitigating Health Risks to Viewers

IES: Illuminating Engineering Society of North America

IES Lighting Handbook

IESNA G-1 Guideline for Security Lighting for People, Property, and Public Spaces

IES RP-1-04, American National Standard Practice of Office Lighting

IES RP-5-13, Recommended Practice for Daylighting

IES RP-8, Roadway Lighting

IES RP-20, Lighting for Parking Facilities

IES LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products

IES LM-80, Measuring Lumen Maintenance of LED Light Sources

IES LM-83, Approved Method: IES Spatial Daylight Autonomy (SDA) and Annual Sunlight Exposure (ASE)

IES TM-15, Luminaire Classification System for Outdoor Luminaires

IES TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources

IEEE: Institute of Electrical and Electronics Engineers

ICEA: Insulated Cable Engineers Association

NEMA: National Electrical Manufacturers Association

NETA: International Electrical Testing Association

NFPA: National Fire Protection Association

NFPA 70, National Electrical Code

NFPA 70E, Standard for Electrical Safety in the Workplace

NFPA 75, Standard for the Fire Protection of Information Technology Equipment

NFPA 76, Standard for the Fire Protection of Telecommunications Facilities

NFPA 101, Life Safety Code

NFPA 110, Standard for Emergency and Standby Power Systems

NFPA 111, Standard on Stored Electrical Energy Emergency and Standby Power Systems

NFPA 780, Standard for the Installation of Lightning Protection Systems

UL: Underwriters' Laboratories

UL50, Enclosures for Electrical Equipment for Types 12, 3, 3R, 4, 4X, 5, 6, 6P, 12, 12K, and 13

UL67, Panelboards

UL 96, Marking and Application Guide Lightning Protection

UL1558, Standard for Metal-Enclosed Low- Voltage Power Circuit Breaker Switchgear

UL1598C, Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits

3.2. Communication System Pathways and Spaces Design Standards

The communications system pathways and spaces must be designed in accordance with the latest edition of the BICSI Telecommunications Distribution Methods Manual and coordinated with NIST to fulfill specific system requirements. Proprietary wireless communication for lighting controls may be considered if scanned and approved by NIST IT. The following standards define the minimum allowable requirements.

Wireless systems must be designed in accordance with the latest edition of the BICSI Wireless Design Reference Manual and coordinated with NIST to fulfill specific requirements.

Electronic Industries Alliance/Telecommunications Industry Association (EIA/TIA) Standards are listed below.

EIA/TIA Standard 568, Commercial Building Wiring Standard (and related bulletins)

EIA/TIA Standard 569, Commercial Building Standard for Telecommunications Pathways and Spaces (and related bulletins)

EIA/TIA Standard 606, Administration Standard for the Commercial Telecommunications Infrastructure (and related bulletins)

EIA/TIA Standard 607, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications (and related bulletins)

EIA/TIA Standard 758, Customer-Owned Outside Plant Telecommunications Cabling Standard

3.3. Load Criteria

The specific electrical power loads must be determined independently for the following load groups:

- Lighting
- Receptacle loads
- Motor and equipment loads
- Elevator and other vertical transportation loads
- Miscellaneous loads

3.3.1. Receptacle Loads

A list of typical receptacle load requirements is shown in Table 6-2. Refer to Section 3.10.2 for further information on the receptacle design conditions and constraints.

Area/Activity	Service Equipment		Distribution Equipment	
	W/m^2	W/ft^2	W/m^2	W/ft^2
Office/enclosed	14.00	1.30	27	2.50
Office open	14.00	1.30	35	3.25
Non-workstation areas	5.00	0.46	10	0.93
Core and public areas	2.50	0.23	5	0.46
Technology/server rooms	540.00	50.18	700	65.06

Table 6-2. Minimum Receptacle Load

3.3.2. Motor and Equipment Loads

Loads associated with motors and equipment must use the rated brake horsepower of specified equipment and nominal full-load efficiencies that meet or exceed those in Chapter 10 of ASHRAE Standard 90.1.

3.3.3. Elevator and Other Vertical Transportation Loads

Electrical power loads for elevators and other vertical transportation equipment must be based on the rated brake horsepower of the specified equipment and nominal full-load efficiencies that meet or exceed those in Chapter 10 of ASHRAE Standard 90.1. Demand factors identified in Chapter 6 of NFPA 70 must be applied.

3.3.4. Miscellaneous Loads

These loads include:

- Security, communication, BAS, and alarm systems
- Heat tracing
- Kitchen equipment
- Central computer servers and data centers
- Uninterruptible power supply (UPS) and battery rooms

Electrical loads for miscellaneous equipment must be based on the rated electrical power requirements or brake horsepower of the specified equipment and on the nominal full-load efficiencies that meet or exceed those in Chapter 10 of ASHRAE Standard 90.1. Demand factors identified in NFPA 70 must be applied.

3.4. Demand Load and Spare Capacity

To ensure maximum flexibility for future systems changes, the electrical system must be sized for

the demand load with additional spare capacity as follows:

Demand factors identified in Chapter 6 of NFPA 70 must be applied.

- Panelboards for branch circuits: 50 percent spare ampacity and 35 percent spare circuit capacity
- Panelboards serving lighting only: 50 percent spare ampacity and 25 percent spare circuit capacity
- Switchboards and distribution panels: 35 percent spare ampacity and 25 percent spare circuit capacity
- Main switchgear: 25 percent spare ampacity and 25 percent spare circuit capacity

All distribution equipment ampacities must be calculated in accordance with NFPA 70, Article 220 and as modified in this chapter. If the addition of 25 or 35 percent spare circuit capacity results in the need for a two-section panel, the design engineer must limit the spares to the capacity of the panel in question and assign sufficient space in the electrical closet layout to accommodate a future panel and associated transformer.

All panelboards must be fully populated with breakers of a size and rating of breakers most frequently used in the panelboard or as directed by NIST.

Before adding the spare equipment ampacity to account for future load growth, it is important that the load study must reflect actual demand loads rather than connected loads. The designer must apply realistic demand factors by considering various energy-conserving devices such as variable frequency drives applied to brake horsepowers, energy-efficient motors, occupancy sensors, and so on. The designer must also avoid adding the load of standby motors and must be careful to distinguish between summer and winter loads by identifying such “noncoincidental” loads. A “diversity factor” must be applied to account for the fact that the maximum load on the elevator system, as a typical example, does not occur at the same time as the peak air conditioning load. Once the estimated “peak demand” load is established, the factor for load growth must be added.

3.4.1. Maximum Voltage Drop

The maximum allowable voltage drop for feeders is 2 percent and for lighting and branch circuits is 3 percent. Both normal and emergency distribution must comply.

3.5. Utility Coordination

3.5.1. NIST Electrical Service Coordination

A detailed load study, including connected loads and anticipated maximum demand loads, as well as the estimated size of the largest motor, must be included in the initial contact with NIST to prepare its personnel for discussions relative to the required capacity of the new electrical service.

The service entrance location for electrical power must be determined concurrently with the development of conceptual design space planning documents. Standards for equipment furnished by NIST must be incorporated into the concept design. Locations of transformers, vaults, meters, and other utility items must be coordinated with the architectural design to avoid conflicts with critical architectural features such as main entrances and must

accommodate both equipment ventilation and equipment removal. All major electrical equipment must be located 5 feet above the 100-year flood plain.

3.5.2. Communications Service Coordination

The telecommunications design professional must contact the local telecommunications providers and coordinate with the client agency and NIST, early in the project to determine the number, size, and location of the incoming services and to determine the enclosure and pathway requirements for telecommunications systems. The scope of services varies with each project; it includes, at a minimum, the design of the infrastructure (pathway and enclosure) and may include the full design and specification of the telecommunications system.

Provision must also be made to provide either cable television (CATV) or satellite service to the facility. CATV or satellite service may be independent from other communications services. The need for multiple space service conduits to accommodate multiple voice/data vendors must be evaluated.

The need for separate redundant internal and external pathways may be required depending on the level of security and mission that may be required by the building occupant.

3.6. Site Requirements

The routing of site utilities and location of manholes must be determined early in the design process in coordination with the NIST COR. All incoming electrical utility feeders shall be installed underground and in concrete (red) duct banks.

ELECTRICAL POWER SERVICES

For buildings less than 100,000 gross square-feet (gsf), the main utilization voltage shall be 480Y/277V or 208Y/120V.

For buildings greater than 100,000 gsf and less than 250,000 gsf, electrical secondary service shall be a minimum of 480Y/277V. For buildings 250,000 gsf and larger, or for campus sites, secondary electrical service must be provided to the building, at medium-voltage distribution, up to 15kV, for primary power distribution to unit substations.

PRIMARY CABLE SELECTION

Medium-voltage cable selection must be based on all aspects of cable operation and on the installation environment, including corrosion, ambient heat, rodent attack, pulling tensions, potential mechanical abuse, and seismic activity. Refer to NIST electrical specifications for requirements.

DIRECT BURIED CONDUIT

If PVC conduit is used, it must be schedule 80. Coated intermediate metallic conduit (IMC) or coated rigid galvanized steel may also be used for the distribution of exterior branch circuits. Backfill around the conduits must be selected based on the thermal conductivity and be free of materials detrimental to the conduit surface.

Direct buried duct banks shall be encased in red concrete and must be continuously indicated by installation of tracer tape 12” above the exterior of the duct bank.

CONCRETE-ENCASED DUCTBANKS

PVC Schedule 40 must be used for all services entering the building (power, communications, and/or life safety) and a minimum conduit diameter of 4in shall be utilized. Where redundant service is required, alternate and diverse paths must be provided. Red concrete (3,000psi) shall be used for all ductbanks.

Concrete-encased ducts must be provided with a cover that is at least 30 in. thick.

Ducts must slope toward manholes and all entries into buildings must have watertight seals. Changes in direction must be by sweeps with a radius of 4 ft) or more. Stub-ups into electrical equipment may be installed with manufactured elbows. Duct line routes must be selected to avoid the foundations of other buildings and structures. Electrical power and communication ducts must be kept clear of all other underground utilities, especially high- temperature water, steam, or gas.

Where it is necessary to run communication cables parallel to power cables, two separate ductbanks must be provided with separate manhole compartments. The same holds true for normal and emergency power cables. Ductbanks must be spaced at least 1 ft. apart.

BICSI Standards govern the installation of telecom infrastructure.

DUCT SIZES AND QUANTITY

Ducts must be sized as required for the number and size of cables. Inner ducts must be provided inside communication ducts wherever fiber optic cables will be used. Spare ducts must be included for planned future expansion; in addition, a minimum of 50 percent spare ducts must be provided for unknown future expansion and/or cabling replacement.

MANHOLES

Manholes must be spaced no farther than 150 m (500 ft.) apart for straight runs. The distance between the service entrance and the first manhole must not exceed 30 m (100 ft.). Double manholes must be used where electric power and communications lines follow the same route. Separate manholes must be provided for low- and medium-voltage systems. Manholes must have clear interior dimensions of no less than 6 ft. in depth, 6 ft. in length, and 6 ft. in width, with an access opening at the top of not less than 30 in. in diameter. Medium-voltage manholes must be sized in accordance with utility company requirements. Manholes must have a minimum wall space of 6 ft. on all sides where splices may be racked.

Manholes must be provided with pulling eyes, sumps, and grounding provisions as necessary.

STUBS

A minimum of two spare stubs must be provided (to maintain a square or rectangular ductbank), so that the manhole wall will not need to be disturbed when a future extension is made.

Stubs for communications manholes must be coordinated with NIST.

HANDHOLES

Handholes may be used for low-voltage feeders (600V and below), branch circuits, or communications circuits. If used, they must be not less than 4 ft. in depth, 4 ft. in length, and 4 ft. in width, and must be provided with standard manhole covers and sumps of the same type provided for manholes. Generally, at least four racks must be installed. Where more than two splices occur (600V feeders only), a 6 ft. by 6 ft. by 6 ft. manhole must be required.

PENETRATIONS

Lighting and communication circuits that penetrate fire walls, fire barriers, fire partitions, smoke barriers, smoke partitions, and between floors must be properly sealed in accordance with the requirements of the IBC with approved firestopping materials.

EXTERIOR CONCRETE

Concrete pads constructed to support exterior mechanical and electrical equipment must be provided with sufficient conduit penetrations to provide the necessary power and control connections plus an additional 50 percent for future equipment additions and modifications. Spare conduits need not extend more than 4 ft. past the end of the concrete slab. All spare conduits must be capped at both ends.

3.6.1. Advanced Building Metering and Controls

3.6.2. All projects must install advanced meters for electricity in accordance with EPAct 2005. Government facilities must be prepared to reduce demand quickly and effectively and include intelligent electric meters capable of bidirectional monitoring of phase voltages, phase currents, power consumption (demand), power factor, kVAR, and availability. These meters must be capable of communicating via BACNET MS/TP. Space Conditions

Provide adequate space and suitable locations for the electrical systems serving the facility and a planned method to install and replace this equipment. During the concept phase, provide detailed space requirements and suggested preferred locations of all critical space requirements for the power and communication systems for the facility. Provide the required space conditions, clear of any structural columns or beams as well as shear walls, stairways, duct shafts, and other obstructions. Equipment space selection must take into consideration adjacencies, such as stairs, mechanical rooms, toilets, elevators, air/piping shafts, and fire-rated assemblies, to permit secondary distribution of electrical and telecommunications circuitry to exit the assigned spaces.

Do not run electrical power or communication systems within stair enclosures unless power or communication serves the stair or is part of the emergency communication system.

3.6.3. Main Equipment Rooms – Electrical and Telecommunications

Main switchgear room doors must be large enough (in width and height) to allow for the removal and replacement of the largest piece of equipment. All equipment doors and personnel

doors must swing out and be provided with panic hardware. Refer to NEC 110.26 for clearance requirements.

The sizes and locations of the telecommunications service rooms must be established in concert with the local communications service provider. Depending on the equipment selected, telecommunication service rooms may require 24-hour HVAC service, and may need protection from contaminants by proper filtration equipment.

Where the application of water from fire sprinklers installed in a main electrical room constitutes a serious life or fire hazard, the main electrical room must be separated from the remainder of the building by walls and floor/ceiling or roof/ceiling assemblies having a fire-resistance rating of not less than 2 hours.

3.6.4. Electrical Rooms

Electrical rooms are generally located within the core areas of the facility and must be stacked vertically. Adequate numbers of electrical rooms must be provided, such that no electrical room serves more than 10,000 sq. ft. and no branch circuit is more than:

1. 120 feet long horizontally for 120V circuits;
2. 250 feet long horizontally for 277V circuits.

Electrical rooms must be provided with minimum unobstructed dimensions of 6 ft. by 10 ft. and are not scalable down in size to match floor plate dimension. A minimum of 30 percent future use wall space must be provided with available NEC clearance. If transformers are located in the rooms, ventilation must be provided.

Electrical rooms are distinct from electrical closets, in that electrical closets shall not contain transformers, motors, or other heat-generating equipment.

3.6.5. Communication Rooms

Communications rooms are also generally located within the core areas of the facility and must be stacked vertically. Adequate numbers of communications rooms must be provided, such that the length of communication cables do not exceed data transmission distance recommendations. Rooms must be sized

to contain adequate floor space for frames, racks, and working clearances in accordance with EIA/TIA standards. Depending on the equipment selected, provisions may be required for 24-hour air conditioning in these rooms. The installation of dedicated electrical panelboards within the communications rooms should be considered to minimize electrical noise and to prevent unauthorized access.

3.6.6. Security Room/Closet

Refer to NIST's ESO site standard document for more information.

3.6.7. Spaces for Uninterruptable Power Supplies and Batteries

Since all UPS systems are considered above standard for ~~GSA~~ NIST space, the requirement for a

UPS system will be a User occupant requirement. To establish the proper size, locations, and environmental requirements for the UPS and battery systems, the electrical engineer must

arrange to meet with the Architect and representatives of the tenant agencies to determine the required/estimated load and physical size requirements and the nature of the critical loads. Refer to the UPS and battery manufacturers' installation instructions for heat dissipation requirements, weights, dimensions, efficiency, and required clearances in the design.

For medium and large systems greater than 50kVA, the UPS system must be provided with standby generator backup to limit the battery capacity. The UPS system equipment and batteries must be in separate rooms if wet cell batteries are utilized. Weight and noise must be considered in UPS placement. Space for storage of safety equipment, such as goggles and gloves, must be provided. Special attention must be given to floor loading for the battery room, entrance door dimensions for installation of the UPS, and ceiling height for clearance of the appropriate HVAC systems and exhaust systems.

3.6.8. Flood Plain Clearance

Electrical equipment must be located at five feet above the 100-year flood plain. Electrical equipment for facilities classified as Critical Action Facilities must be located five feet above the 500 year flood plain. The electrical engineer must determine from local jurisdictions any additional freeboard requirements above this base level.

3.7. Distribution System Alternatives

3.7.1. Primary Distribution

The primary distribution methods on-site are: radial primary, primary selective and secondary selective.

Mission critical facilities shall be provided with dual utility feeders, having a primary selective-secondary selective configuration. Design of the medium-voltage switchgear must meet all of the requirements UL1558. Switchgear must be provided with enclosed, drawout-type vacuum interrupter breakers, one per each size fully equipped spare cubicle/breakers up to 1,600 amps, a breaker lifting device, and a ground and test device. The ground and test device must be stored in a spare switchgear cubicle.

Voltmeters, ammeters, and watt-hour digital meters with demand registers on each feeder must be provided for medium-voltage switchgear in addition to approved digital relaying. Meters must be digital pulse-type for connection to and monitoring by the Advanced Metering Equipment. IR camera inspection ports shall be provided on the enclosure of all medium voltage switchgear for ease of inspecting switchgear for thermal problems while under load.

All switchgear sections must be installed on four- inch concrete housekeeping pads.

3.7.2. Network Transformers

Network transformers must be liquid filled. Refer to NIST Electrical specifications for more information.

3.7.3. Double-Ended Substations

Where either a primary selective or primary selective-secondary selective (double-ended) substation is selected, the following paragraph applies:

If reliability is critical and spot networks are not feasible, double-ended substations must be used. Transformers must be equipped with provisions for fans to increase the rated capacity. The sum of the estimated demand load of both ends of the substation must not exceed the rating of either transformer and must not exceed the fan cooling rating. All double-ended substations must be equipped with two secondary main breakers and one tie breaker configured for open transition automatic transfer, initiated through the use of an under-voltage relaying scheme. Breakers must be of the electrically operated, drawout type.

3.7.4. Network Substations

All circuit breakers up to and including the secondary switchgear main circuit breaker must be drawout type.

3.7.5. Transformers

Refer to NIST electrical specifications for more information.

3.7.6. Network Protectors

Where spot networks are installed, network protectors shall be installed at the output of each network transformer to maintain service continuity and provide primary feeder protection for through faults.

3.8. Secondary Distribution

3.8.1. Main Switchgear

In the case of double-ended substations, all main and secondary feeder breakers must be draw-out power type.

All breakers in the service main switchgear must be fully rated. Series rating is not permitted. Main and feeder breakers must be provided with integral solid-state ground-fault protection tripping elements. IR windows for each vertical compartment shall be provided.

Where feasible, arc resistant gear shall be considered in the design process.

3.8.2. Surge Suppression

Surge suppression on the main incoming service secondary switchgear must be provided.

3.8.3. Switchgear Metering

All main switchgear metering sections must contain a power quality meter capable of reading all system voltages, system currents, system power (reactive and real), system harmonics and have waveform capture capability. The power meter must be networked and tied into the Building Automation System.

3.9. Secondary Branch Power Distribution

3.9.1. Feeder Assignments (Bus Ducts vs Cable in Conduit)

For feeders 1600A and above, bus duct (feeder bus) is the preferred method for power distribution.

3.9.2. Bus Duct

Bus ducts must be copper or aluminum, fully rated, 3-phase, 3-wire or 3-phase, 4-wire with 100 percent neutral, and an integral ground bus, sized at 50 percent of the phase bus, NEMA Class 3R

or higher. Short circuit withstand ratings shall be coordinated with upstream overcurrent protective device(s).

3.9.3. Motor Control Centers

Motor control center (MCC) construction must be NEMA Class I, Type B copper, with magnetic (or solid-state if appropriate) starters and either molded case solid state circuit breakers or fused switches. The minimum starter size in motor control centers must be Size 1. MCCs must be provided with Advanced Metering for remote monitoring.

Control circuit voltage must be 120V connected ahead of each starter via a fused control transformer. Reduced-voltage starters may be used for larger motors to reduce starting kVA.

Time-delay relays must be incorporated in the starters or programmed in the BAS system to reduce inrush currents on the electrical system.

Arc resistant designs shall be considered during the design process.

3.9.4. Elevator and Other Vertical Transportation Power

If two or more switchgears are available, the load of the elevator and other vertical transportation feeders must be divided among the secondary switchgears, provided that alternate elevator machines must be fed from different switchgears.

Note: One elevator in each bank must be connected to the emergency generator. Where multiple elevators are in a common bank, provide a common emergency feeder from the elevator automatic transfer switch (ATS) to allow each elevator to be operated individually during an emergency. Interlocking the ATS with the elevator group controller, programming must be made by the elevator supplier to set up a controlled return to the terminal floor and then to limit the number of elevators in that bank that can be run concurrently.

Elevator machines must be electrically powered by non-auto resetting circuit breakers with padlocking capabilities. Shunt trip circuit breakers must be provided when automatic sprinklers are installed in hoist ways, machine rooms, and control rooms containing elevator driving machines. The electrical supply shall disconnect automatically prior to application of water. Elevator breakers must be located in the elevator machine room.

3.9.5. Variable Frequency Drives

All VFDs must be provided with a contactor bypass option. All motors sized 5 horsepower and larger shall be provided with either Shaft Grounding Rings (SGRs) or Common Mode Filters to eliminate high frequency damage to motor bearings.

VFDs must use a minimum 6-pulse width modulation (PWM) design because of their excellent power factors and high efficiencies. VFDs must be specified with passive harmonic filters and with isolation transformers where required. Individual or simultaneous operation of the variable frequency drives must not add more than 5 percent total harmonic voltage distortion nor more than 10 percent while operating from the standby generator (if applicable), per IEEE 519, latest edition. The input to the site's High-Speed Switch shall be the point of common coupling.

A harmonic (voltage and current) analysis must be conducted by the electrical engineer, including all calculations, and submitted in accordance with Appendix A.

Where the harmonic analysis indicates noncompliance, the application of 12-pulse, pulse width modulation, or zig-zag transformers or other approved alternate method must be used to reduce the total harmonic voltage distortion.

Distance between VFDs and their load shall not exceed VFD manufacturer's recommendations. VFD rated wire shall be provided between the VFD and the motor being served.

3.10. Branch Wiring Distribution Systems

3.10.1. Lighting Circuit Loading

120-volt circuits must be limited to a maximum of 1,400 volt-amperes. 277-volt circuits must be limited to a maximum of 3,200 volt-amperes.

3.10.2. Receptacle Circuit Loading

120-volt circuits must be limited to a maximum of 8 duplex receptacles.

Each special purpose receptacle must be circuited on a dedicated circuit to a protective device to match the rating of the receptacle.

The color of standard receptacles and switches must be coordinated with the architectural color scheme; for example, white, not ivory, devices must be used if walls are white or light gray. Special use receptacles shall follow the color standard in NIST Electrical Specifications.

Building standard receptacles must be duplex, specification-grade NEMA 5-20R. Each Ground Fault Circuit Interrupter (GFCI) receptacle must have a light indicating when it has been tripped. Communication room equipment receptacles must be locking type to prevent accidental disconnection. Special purpose receptacles must be provided as required. Device plates must be plastic, colored to match the receptacles.

3.10.3. Placement of Receptacles

CORRIDORS

Receptacles in corridors must be located 15 m (50 ft.) on center and 7.5 m (25 ft.) from corridor ends.

OFFICE SPACE

Receptacles for housekeeping must be placed in exterior walls and walls around permanent cores or corridors. Where receptacles are placed on exterior walls, installation of conduits and wallboxes must minimize air infiltration and moisture incursion. Gray wireway shall be used to provide a raceway for branch circuit wiring and for device mounting. Each office shall receive four (4) receptacles, one on each wall.

Placement of receptacles in walls must be avoided where raised access floors are used. See Section 3.10.4, Underfloor Raceway Systems, for additional requirements. For areas where

raised access floors or underfloor raceway systems are not used, placement of receptacles must comply with the project requirements.

CONFERENCE AND TRAINING ROOMS

Conference rooms and training rooms will have specific user requirements.

MAINTENANCE SHOPS

Maintenance shops require plug-mold strips above work benches with duplex outlets 36 in. on center. Receptacles must be wired on alternating circuits. Receptacles or circuit breakers must be of the ground fault interrupt (GFI) type. Coordinate emergency power off stations with user equipment and/or requirements.

COMMUNICATIONS ROOMS

Communication rooms must contain power and grounding for the passive and active devices used for the telecommunications system, including at least two dedicated 20A, 120 volt duplex electrical outlets on emergency power, and additional lock type convenience outlets at 6 ft. intervals around the walls and direct connection to the main building grounding system. If uninterruptible power is required in communications rooms, it must be furnished as part of the communications system. Larger communication rooms must be provided with ceiling-mounted locking receptacles on ceiling- hung strain relief whips.

MECHANICAL AND ELECTRICAL ROOMS

All mechanical and electrical equipment rooms must each have, at a minimum, one emergency power receptacle that is identified as such at the receptacle.

EXTERIOR MECHANICAL EQUIPMENT

Provide one receptacle adjacent to mechanical equipment exterior to the building, including each roof section. Receptacles must be of the weatherproof GFCI type. Receptacles must be located within 25 ft. of each piece of equipment in accordance with NFPA 70 210-63.

TOILET ROOMS

Each toilet room must have at least one GFCI receptacle at the vanity or sink. All receptacles located in toilet rooms must be GFCI protected.

Carefully coordinate the location of the receptacles with all toilet accessories.

3.10.4. Underfloor Raceway Systems

Underfloor raceways fall into three categories:

RAISED ACCESS FLOORS

All wiring beneath a raised access floor must meet the requirements in NFPA 70 and must be routed in conduit to underfloor distribution boxes. Flush-mounted access floor service boxes must be attached to the underfloor distribution boxes by means of a modular, prewired system to facilitate easy relocation. All above shall be coordinated with NIST.

3.10.5. Panelboards

Panelboards must be constructed to comply with the requirements of UL 67 and UL 50.

All panelboard interiors must be constructed using hard-drawn copper of 98 percent conductivity, with AIC bracing greater than the calculated, maximum available fault current. No series rated systems are allowed. A full-size copper ground bus for connecting ground conductors must be bonded to the steel cabinet.

Branch circuit breakers must be bolt-on designed for replacement without disturbing the adjacent units. Breakers must comply with the requirements of UL 489, thermal magnetic type with a short-circuit rating greater than the calculated, maximum available fault current. Panels must be specified with “door-in-door” trim.

PANELBOARD SURGE PROTECTION

All new emergency panelboards shall be provided with integral surge protection devices as required by NFPA 70, section 700.8.

Panelboard circuits feeding outside loads (lighting, receptacles, charging stations, etc.) shall also be protected with type 2 SPDs if building lightning protection is provided.

3.10.6. Conductors and Conduit Systems

The specification must list the various types of conduit systems that are approved for use on the

project and the specific raceway applications for which they are to be used. MC cabling is not an acceptable conduit system. Approved conduit systems are as follows:

RSC – Rigid galvanized steel conduit – ANSI C80.1 Exposed outdoors, wet, or damp locations

RAC – Aluminum conduit (with steel elbows) Indoor feeders – exposed and/or concealed

IMC – Intermediate steel conduit – ANSI C80.6 Exposed outdoors, wet, or damp locations. Indoor feeders, exposed and/or concealed

EMT – Electrical metallic tubing (full compression steel fittings) – ANSI C80.3 Branch circuit wiring, exposed and/or concealed

FMC – Flexible steel conduit – connections to recessed lighting fixtures, motors, or concealed in movable wall partitions.

LFMC – Liquid flexible steel conduit with PVC jacket. Connections to vibrating equipment (motors, transformers, etc.)

PVC – Underground feeders encased in concrete envelope. Indoors and outdoors. Transition to steel or aluminum when not encased.

CONDUCTORS

Aluminum or copper conductors are acceptable for motor windings, distribution transformer windings, switchgear bussing, and switchboard bussing, where the conductor is purchased as part of the equipment.

Conductor insulation shall be colored in accordance with the following:

(208/120V: A-black, B-red, C-blue, neutral- white, ground-green, isolated ground-green w/ yellow stripes)

(480/277V: A-brown, B-orange, C-yellow, neutral-gray, ground-green w/ yellow stripes, isolated ground-green w/ yellow stripes)

MC cable may be used for portions of branch circuits not excluded below and that do not terminate directly at a panelboard.

MATERIALS AND CONSTRUCTION

Metal-Clad Cable shall be steel armored and not exceed #10 AWG.

Metal-Clad Cable shall be labeled a minimum of every three feet with 360-degree paint bands indicating number of conductors and voltage (either 480/277V or 208/120V) of conductors

All circuit home runs shall be in conduits and labeled. Conduit systems must be used between the panelboard and the first terminated device.

All accessible and serviceable Metal-Clad Cable runs shall be provided with permanent typed labels every 10 feet and at all wall penetrations with tags indicating panelboard and circuit feed from.

Individual Metal-Clad Cables shall NOT contain more than three current carrying conductors to prevent having to derate the cables due to heat; however, integral lighting control conductors are acceptable for lighting circuits.

Metal-Clad Cable shall be secured to the structure as stipulated in the National Electric Code unless otherwise noted in this document. All cables shall be secured within 12 inches of the cable termination device.

Snap in type fittings shall not be used.

Metal-Clad Cable shall not be used in the following areas:

In highly finished spaces such as historical areas, lobbies, and conference centers

In wet, damp, hazardous, chemical using areas, outdoor structures, basements, garages, penthouses, elevator shafts, mechanical rooms/spaces, or areas subject to physical damage from vehicular or maintenance equipment

Metal-Clad Cables shall NOT be directly embedded in concrete structures/columns or below unmovable flooring (e.g., hardwood flooring)

Metal-Clad Cable shall not be directly embedded in finished plaster surfaces

Metal-Clad Cable shall NOT be used to feed either building or tenant critical electrical infrastructure such as servers, HVAC, intrusion detection, access control and fire alarm/protection systems.

3.10.7. Equipment Labelling

All electrical equipment installed must be provided with exterior, typewritten, machine- made labels indicating the panel and circuit number from which they electrically fed in conformance with NEC 408.4 Field Identification Required and site specification requirements. This requirement applies to all electrical cover plates, lighting switch plates, disconnects, transformers, etc.

3.10.8. Voice and Data Distribution System

The configuration and type of the voice and data cabling distribution systems must be developed at the earliest stages of design, since the space requirements are so significant and widespread. System requirements are user generated and are generally translated into distribution system requirements by the design engineer in conjunction with NIST.

3.10.9. Equipment Grounding Conductor

Except for isolated ground and other specialty grounding systems, all low- voltage power distribution systems must be supplemented with a separate, insulated equipment grounding conductor.

3.10.10. Communication Raceways

Communication raceways must meet the installation requirements in NFPA 70.

OFFICES

Gray wireway shall be used to provide a raceway for communication wiring and for device mounting. Each office shall receive two (2) data outlets coordinated with placement of the office's 120V receptacles.

RAISED ACCESS FLOOR

If NIST has determined that raised access floors are to be used for cable management in the project, the communications services must be installed by laying the cable in a tray for main runs and then branching directly on the floor slab below the raised access flooring system.

CABLE TRAYS IN HUNG CEILINGS

Since underfloor raceway systems cannot accommodate the large turning radii required by the CAT 6 and fiber optic cables, the primary alternative to a raised floor system is a series of cable trays installed above accessible hung ceilings. Cable trays must be continuously grounded.

3.11. Emergency and Standby Power Systems

Emergency and standby power systems must be designed to comply with the requirements of the IBC, NFPA 110, and NFPA 111. Compliance with the electrical safety of the installation, operation, and maintenance of emergency systems is required, as addressed in Article 700 of NFPA 70. Unless otherwise specifically authorized by the contracting officer, all facilities must be provided with a standby generator to supply power to the facility in the event of a sudden loss of power.

3.11.1. Classification of Emergency Power Supply Systems

The class and type of Emergency Power Supply Systems (EPSSs) for Federal buildings must be a minimum of Class 72, where 72 is the minimum time in hours for which the EPSS is designed to

operate at its rated load without being refueled (see Chapter 4, NFPA 110). The EPSS must have a designation of Type 10, where 10 is the maximum time in seconds that the EPSS will permit the load terminals of the transfer switch to be less than 90 percent of the rated voltage.

Where the standby generator supplies a switchboard, power may be distributed from the switchboard to the emergency, legally required standby, and optional standby systems, in accordance with Figure B.1 (a) and B.1 (b), NFPA 110.

EMERGENCY SYSTEM

The EPSS must supply emergency loads through an automatic transfer switch upon failure of the normal supply. The transfer time limit must not exceed 10 seconds. At all critical facilities, automatic transfer switches shall be provided with maintenance bypass switches to allow the automatic transfer switch to be maintained while still providing power to the building. Emergency illumination must include all required egress lighting, illuminated exit signs, and all other lights specified as necessary to provide required illumination.

An emergency supply source must supply equipment classified as emergency through an automatic transfer switch upon failure of the normal supply.

Emergency loads (life safety loads) must include:

- Emergency lighting
- Fire alarm system
- Exit signs
- Automatic fire detection equipment for smokeproof enclosures
- Emergency voice/alarm communication systems
- Smoke control systems
- Exit stairway pressurization systems
- Fire pump
- Pressure maintenance (jockey) pump
- Air compressors serving dry pipe or pre- action systems
- Power and lighting for fire command center and security control center
- Fire service access elevators and associated controllers and the cooling and ventilation equipment serving their machinery rooms and machinery spaces (simultaneously all designated elevators)
- Occupant evacuation elevators and associated controllers and the cooling and ventilation equipment serving their machinery rooms and machinery spaces (simultaneously all designated elevators)

REQUIRED STANDBY SYSTEM

This system must automatically supply power to selected loads (other than those classified as the emergency system) upon failure of the normal source. The transfer time limit must not exceed 60 seconds.

Required standby loads must include:

- Visitor screening equipment

- Telephone switches and fiber cable battery systems
- Security systems
- Mechanical control systems
- BASs
- Sump pumps
- Sewage ejection pumps
- Uninterruptible power systems serving technology/server rooms
- HVAC systems for technology/server rooms, UPS rooms, and communications rooms
- Exhaust fan in UPS battery rooms

OPTIONAL STANDBY SYSTEM

This system must supply power to the facilities or property where life safety does not depend on the performance of the system. The optional standby system must supply on-site generated power to selected loads, either automatically or by manual transfer.

Optional standby system loads may include:

- General areas of the buildings
- HVAC and refrigeration systems
- Data processing and communications systems
- Boiler, hot water pumps, perimeter HVAC units, and any other ancillary heating equipment necessary to freeze-protect the building
- Receptacles and emergency lighting in large conference rooms to facilitate command and control operations during an emergency.

3.11.2. Generator Systems

The emergency and standby generator system must consist of one or more central engine generators and a separate distribution system with automatic transfer switches, distribution panels, lighting panels, and, where required, dry- type transformers feeding 208/120V panels.

Diesel fuel and natural gas are permitted as energy sources for building emergency generators. However, if natural gas/propane is selected for level 1 and mission critical facilities that may be located in areas where the probability of fuel interruptions is high (due to earthquakes, floods, poor utility reliability, or operational/facility requirements), the A/E shall develop a risk assessment (e.g., probability and consequences) that analyzes these types of parameters. This assessment shall also address issues such as block loading limitations, building height, seismic zone, continuity of tenant mission requirements, facility security, etc. NIST will make the final determination as to the fuel source assessment that will be utilized.

Generators shall be registered with the applicable regulatory authority.

Generators shall be certified as fully EPA compliant at the manufacturing facility.

SERVICE CONDITIONS

If possible, locate the generators outside and on grade. If installed outdoors, they must be provided with a suitable walk-in acoustic enclosure and jacket water heaters to ensure reliable starting in cold weather. If critical action structures must be located within a floodplain, generators shall be elevated above the 500-year base flood elevation. When installed at high altitudes or in areas with very high ambient temperatures, the generators must be derated in accordance with manufacturers' recommendations. Operation of starting batteries and battery chargers must also be considered in sizing calculations. Critical silencers are required for all generators. Acoustical treatment of the generator room must be provided as necessary. Temperature and ventilation must be maintained within the manufacturers' recommendations to ensure proper operation of the unit. Calculations to support the size of the intake air supply for combustion, cooling, and radiation, as well as exhaust piping and exhaust paths, must be provided by the mechanical engineer.

Radiators must be unit mounted if possible. If ventilation is restricted in indoor applications, remote installation is acceptable. Heat recovery and load shedding must not be considered. The remote location of radiators must be designed to avoid excess pressure on the piping seals.

Load bank connection points shall be considered for generators rated at 500kW and above.

CAPACITY

The engine generators must be sized to serve approximately 150 percent of the design load and to run at a maximum of 60 percent to 80 percent of their rated capacities after the effect of the inrush current declines. When sizing the generators, the initial voltage drop on generator output due to starting currents of loads must not exceed 15 percent. Belly tanks must be sized for a minimum capacity of twenty-four hours of generator operation. Provide direct fuel oil supply and fuel oil return piping to the on-site storage tank.

Piping must not be connected into the boiler transfer fuel oil delivery "loop."

Care must be exercised in sizing fuel oil storage tanks by taking into account that the bottom 10 percent of the tank is unusable and that the tank is normally not full (normally at a 70 percent level) before the operation of the generator.

GENERATOR ALARMS

Generator alarms must be provided via a generator annunciator. The generator output breaker must have a contact connected to the BAS indicating output breaker position, to allow annunciation of the open position on the BAS.

AUTOMATIC TRANSFER SWITCHES

Automatic transfer switches serving motor loads must have in-phase monitors (to ensure transfer only when normal and emergency voltages are in phase) to prevent possible motor damage caused by an out-of-phase transfer. They must also have pretransfer contacts to signal time delay returns in the emergency motor control centers.

Automatic transfer switches may include a bypass isolation switch that allows manual bypass of the normal or emergency source to ensure continued power to emergency circuits in the event of a switch failure or required maintenance. Bypass isolation will be specific to the project/user requirements.

LOCATION

The generators and the generator control panel must be located in separate rooms or enclosures.

LOAD SHEDDING

Life safety generators may be designed to operate in parallel with the local utility, thus allowing for load shedding and smart grid and intelligent building initiatives. Before designing emergency generators for peak shaving purposes, local, State, and Federal authorities must be contacted due to the need for possible noise, air quality permitting, and additional hardware requirements.

3.12. Clean Power Systems

3.12.1. Uninterruptable Power Supplies and Battery Rooms

In some facilities, technology/server room backup systems are designed by the tenant agency. If this is the case, shell space and utility rough-ins must be provided. In facilities where UPS systems are to be provided as part of the building construction, they must be designed as described in this section. All UPS systems are considered to be above standard for NIST space. Tenant agencies with UPS requirements should be advised that a maintenance contract is recommended.

Requirements for UPS systems must be evaluated on a case-by-case basis. If UPS is required, it may or may not require generator backup. When generator backup is unnecessary, sufficient battery capacity must be provided to allow for an orderly shutdown.

CRITICAL TECHNICAL LOADS

The nature, size, and locations of critical loads to be supplied by the UPS will be provided in the program. Noncritical loads must be served by separate distribution systems supplied from either the normal or electronic distribution system. A UPS system must be sized with at least a 25 percent spare capacity. The specification of a redundant module must depend upon the criticality of the loads.

EMERGENCY ELECTRICAL POWER SOURCE REQUIREMENTS

When the UPS is running on the site emergency generator, the amount of current to recharge the UPS batteries must be limited to not overload the generator. This limited battery charging load must be added to the required standby load when sizing the standby generator.

If the UPS system is backed up by a generator to provide for continuous operation, the generator must provide power to all necessary auxiliary equipment, i.e., the lighting, ventilation, and air conditioning supplying the UPS and the critical technical area.

SYSTEM STATUS AND CONTROL PANEL

The UPS must include all instruments and controls for proper system operation. The system status panel must have an appropriate audio/visual alarm to alert operators of potential problems. It must include the following monitoring and alarm functions: system on, system bypassed, system fault, out of phase utility fault, and closed generator circuit breaker. It must have an audible alarm and alarm silencer button. Since UPS equipment rooms are usually unattended, an additional remote system status panel must be provided in the space served by the UPS. The alarms must also be transmitted to the BAS.

UPS AND BATTERY ROOM REQUIREMENTS

Emergency lighting must be provided in both spaces and a telephone must be provided in or adjacent to the UPS room. The battery room design must provide proper ventilation, hydrogen detection, spill containment, and working clearances.

3.12.2. Computer Center Power Distribution Unit

In some cases, the power distribution system for computer centers is designed by the tenant agency. If this is the case, utility rough-in must be provided under the construction contract. If power distribution is to be provided under the building contract, it must be designed according to the criteria in this section.

POWER DISTRIBUTION UNITS (PDUS)

PDUs with internal or remote isolation transformers and output panelboards must be provided in all computer centers to reduce/eliminate harmonic currents generated by nonlinear loads and reflected back to the neutral service conductors. PDUs with internal or remote isolation transformers must be harmonic mitigating to serve nonlinear loads.

COMPUTER CENTER GROUNDING

To prevent electrical noise from affecting computer system operation, a low-frequency power system grounding and a high-frequency signal reference grounding system must be provided. The design of the technology/server room grounding system must be coordinated with the computer center staff.

LOW-FREQUENCY POWER SYSTEM GROUNDING

A safe, low-frequency, single-point grounding system must be provided that complies with Article 250 of NFPA 70. The single-point ground must be established to ground the isolation transformer or its associated main service distribution panel.

A grounding conductor must be run from the PDU isolation transformer to the nearest effective earth grounding electrode as defined in NFPA 70. All circuits serving automated data processing equipment from a PDU must have grounding conductors equal in size to the phase conductors.

HIGH-FREQUENCY POWER SYSTEM GROUNDING

A high-frequency signal reference grounding system shall consist of a grid made up of 2 ft. squares must be provided as a signal reference grounding system. If a raised floor has been

provided, its grid with mechanically bolted stringers may be used. Alternatively, a grid can be constructed by laying a 2 ft. squares of braided copper strap or 16 gauge, 0.051 in.by 2 in. copper strap directly on the structural floor. Data processing equipment must be connected to the reference grid by the most direct route with a braided copper strap.

COMMON-MODE NOISE REDUCTION

The following steps must be taken to reduce common-mode noise:

- Avoid running unshielded metallic signal or data lines parallel to power feeders.
- Where metallic signal or data lines are routed in noise-prone environments, use shielded (grounded at one end) cables or install wiring in ferrous metal conduit or enclosed cable trays.
- Locate metallic signal or data lines and equipment at a safe distance from arc- producing equipment such as line voltage regulators, transformers, battery chargers, motors, generators, and switching devices.
- Provide isolation transformers, electronic power distribution panelboards, or power conditioners to serve critical electronics equipment loads.
- Provide isolated grounding service on dedicated circuits to critical data terminating or communicating equipment.
- Replace metallic data and signal conductors with fiber optic cables where practical.

3.12.3. Harmonic Mitigation – Transformers

To accommodate/correct harmonics associated problems, the electrical design must utilize Harmonic Mitigating Transformers rated distribution transformers.

Application of these engineered strategies shall be confirmed by a harmonic (voltage and current) analysis submitted to NIST for evaluation and review.

Transformer efficiencies of all building transformers shall meet or exceed 10 CFR 431, part 196.

3.13. Grounding Systems

Grounding systems must be designed to coordinate with the specific type and size of the electrical distribution system, including the following applicable generic types of grounding systems or grounding components.

3.13.1. Separate Equipment Ground Conductors

The types, sizes, and quantities of equipment grounding conductors must comply with NFPA 70, Article 250, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

Insulated equipment grounding conductors must be installed with circuit conductors for the following items, in addition to those required by NFPA 70:

- Feeders and branch circuits
- Lighting circuits
- Receptacle circuits
- Single-phase motor and appliance branch circuits

- Three-phase motor and appliance branch circuits
- Flexible raceway runs
- Metal clad cable runs
- Cabletrays (bond each individual section)

3.13.2. Busway Supply Circuits

Insulated equipment grounding conductors must be installed from the grounding bus in the

switchgear, switchboard, or distribution panel to the equipment grounding bar terminal on the busway.

3.13.3. Separately Derived Grounds

To minimize extraneous "noise" on certain systems, particularly those in which harmonics are generated, the specific system grounds must be separated before grounding at the service grounding electrode or counterpoise.

3.13.4. Raised Floors

All access floors must be grounded. A grounding conductor must be bonded to every other floor pedestal and must be extended to the technology/server room common ground bus.

3.13.5. Counterpoise

Where feasible, a grounding conductor (counterpoise) must be provided in an isosceles triangle configuration with sides greater than or equal to 10 ft. The conductor must be tinned copper not less than No. 4/0 AWG and must be electrically connected to the incoming domestic water services (provided the piping for the water service is a conducting material) on either side of the building as well as the various clusters of three ground rods spaced at intervals. Ground rods must be 5/8 in. diameter by 96 in. long and must be zinc coated copper. The counterpoise loop will involve direct burial in earth 24 in. below grade. The following items must be connected to the counterpoise loop. All ground rod and grounding connections must be exothermically welded:

- Lightning protection system "down conductors"
- Transformers in substations
- Emergency generator ground
- Telecom and data room grounds
- Separately derived grounds
- Isolated ground panels
- Main switchgears
- Normal and emergency distribution systems
- Flagpoles

3.13.6. Common Ground System

Consideration should be given to providing a common ground bus throughout the building. Conceptually a common ground bus would originate from the main service entrance and run up through stacked electrical rooms, where an insulated wall-mounted copper ground plate would

be installed for connecting any equipment needing a common ground. Where conditions might prohibit an isosceles triangle counterpoise ground, consideration should be given to installing chemical ground rods in trenches or borings supplemented with conductivity- enhancing soil conditioners such as Bentonite clay or conductive concrete.

3.14. Safety Systems, Equipment and Personal Protection

3.14.1. Lightning Protection Systems

Lightning protection systems are important safety features in the design of electrical distribution systems. Their application on any specific project is a function of its geographic location, height, proximity of taller adjacent structures, regional ground resistance, and the architectural configuration of the building. The decision to provide a lightning protection system must be made at the earliest stages of design and must be supported by a study, as prescribed by NFPA 780.

If a decision is made to provide a lightning protection system, specify that it be installed in compliance with NFPA 780 and the components meet the requirements of UL 96.

ALTERNATE SYSTEMS

The requirement of a UL certification imposes certain restrictions or limitations on the design of the system, which may be in conflict with the architectural design, particularly if the facade includes large curved surfaces that preclude the installation of air terminals and where the spacing of down conductors is limited. In those instances, the electrical engineer may appeal to the contracting officer to waive the UL certification requirement on the basis that the design generally follows the Faraday Cage principle of lightning protection.

GROUNDING

The down conductors must follow direct paths from the air terminals to the ground connections or to the counterpoise loop. Lightning ground conductors should have long sweeping bends and not hard 90-degree bends forcing them to conform to architectural building features.

3.14.2. Security Systems

Every Government building, virtually without exception, whether new or existing, large or small, recent vintage or historic, must have provisions for a security system. The type and level of security system must be determined by ESO and the client agency. The security requirements must be integrated into the design for the project. The systems must be integrated with the emergency and standby power systems.

3.14.3. Short Circuit and Coordination Studies

The electrical engineer must submit a preliminary short circuit analysis on all projects. The final coordination and analysis must be completed by the electrical contractor's testing agency or by an independent agency, and a report must be submitted as part of the commissioning process (see Chapter 1 for commissioning requirements). The building power system model shall be provided in a format coordinated by the region. NIST shall be provided the source code for the analysis and have rights to the source native files at no additional cost to the Government.

ARC FLASH AND ARC ENERGY

The design engineer must submit a computer- generated arc flash analysis for the entire building electrical distribution system. The data from the arc flash calculations for individual pieces of electrical equipment must be transposed to NFPA 70E-approved labels and all panelboards, motor control centers, switchgear, and major electrical equipment must be appropriately labeled and protection boundaries delineated per OSHA 1910 Subpart S and NFPA 70E requirements. New and refurbished equipment shall conform to NEC 240.87.

3.15. Solar Voltaic Systems

The installation of solar photovoltaic (PV) systems presents concerns for safety (energized equipment, trip hazards, etc.) and firefighting operations (restricting venting locations, limiting walking surfaces on roof structures, etc.). The intent of the requirements below is to address these issues while embracing the environmental advantages of this technology.

Be cognizant that because of the growing demand for PV system products, manufacturers are developing new products and methods daily and therefore GSA may encounter PV systems

that will require an alternative means of compliance. Please note that it is not intended to prohibit the use of alternative systems, methods, or devices not specifically prescribed, provided GSA approves all proposed alternatives.

Before the PV system installation, the GSA project manager must meet with the contractor, GSA property manager, GSA fire protection engineer, GSA safety specialist, local power utility company, and local fire official to ensure the proposed PV system design and layout is acceptable to all parties.

Before the acceptance of the PV system, the GSA project manager must confirm that the PV system has been tested. All testing must be witnessed and documented by a qualified independent third-party test entity. The third-party test entity must have an advanced understanding of the installation, operation, and maintenance of the PV system installed. The project's commissioning agent must witness the PV system testing. At the completion of witnessing the PV system testing, the project's commissioning agent entity must provide to the GSA project manager documentation verifying that the PV system complies with the design and specifications.

3.15.1. Requirements

The installation of PV systems at GSA Federal buildings must comply with the requirements in the International Building Code, International Fire Code, and National Fire Protection Association (NFPA) 70, National Electrical Code.

3.15.2. Marking

PV systems must be marked in accordance with NFPA 70, Article 690, and the following:

3.15.3. Smoke Ventilation

The PV system must be designed such that smoke ventilation opportunity areas are provided on the roof and meet the following requirements:

Each array must be no greater than 150 x 150 feet in distance in either axis.

Ventilation options between array sections must meet one of the following:

- A pathway 8 feet or greater in width;
- A pathway 4 feet or greater in width that borders on existing roof skylights or ventilation hatches; or,
- A pathway 4 feet or greater in width bordering 4 ft. x 8 ft. “venting cutouts” every 20 feet on alternating sides of the pathway.

3.15.4. Location of DC Conductors

Exposed conduit, wiring systems, and raceways for PV circuits must be located as close as possible to the ridge or hip or valley on the roof to reduce trip hazards and maximize ventilation opportunities.

Conduit runs between subarrays and conduit runs to DC combiner boxes must be designed in a manner that minimizes total amount of conduit on the roof. The DC combiner boxes must be located such that conduit runs are minimized in the pathways between arrays.

To limit the hazard of cutting live conduit in fire department venting operations, DC wiring must be run in metallic conduit or raceways when located within enclosed spaces in a building and must be run, to the maximum extent possible, along the bottom load-bearing members.

3.15.5. Roof Clearance Requirements

The PV system, including supports and power conductors, must not interfere with roof drains, expansion joints, air intakes, existing electrical

and mechanical equipment, existing antennas, and planned areas for future installation of equipment.

Rooftop installation must coordinate with the building rigging plan associated with powered platforms, boatswain chairs, etc., and address the relocation or incorporation of the davits.

In addition to the pathway requirements noted above, a 3-foot clear path of travel must be maintained to and around all rooftop equipment.

3.15.6. Roof Mounting Requirements

Mounting systems must be either fully ballasted or must limit penetrations of the roofing system. All roof penetrations must be designed and

constructed in collaboration with the roofing professional or manufacturer responsible for the roof and roofing material warranty for the specific site. The number and size of the penetrations necessary to extend the power and control cable into the building must be kept to a minimum and grouped in a single location when practicable. All weatherproofing of penetrations must be compatible with the roof warranty.

3.15.7. Equipment and Components

All PV hardware and structural components must be either stainless steel or aluminum. All interconnecting wires must be copper. Power provided must be compatible with on-site electric distribution systems.

3.15.8. Safety

Provide detailed Lock Out/Tag Out instructions for all equipment.

Provide lightning protection meeting UL96 and NFPA 780.

PV Modules must be UL Listed and must be properly installed according to manufacturer's instructions, IBC, IFC, and NFPA 70.

3.15.9. Required: PV System Approval

Before PV system installation, the GSA project manager must ensure the proposed PV system design and layout is acceptable to all parties:

- GSA Property Manager
- GSA Fire Protection Engineer
- GSA Safety Specialist
- Local fire officials

3.16. Quality Assurance of Electrical Power Systems and Equipment

Electrical acceptance and commissioning specifications should describe the systematic process of documenting, assessing the suitability for initial energization, placing into service, and final acceptance of newly installed, or retrofitted electrical power equipment and systems.

ANSI/NETA ATS and ANSI/NETA ECS must be consulted and referenced when defining these specifications. Continued quality assurance relies on routine, preventive maintenance as specified by the ANSI/NETA MTS.

3.16.1. Electrical Testing firm

Accredited, third-party, field-experienced, electrical testing firms or OEM certified technicians should be utilized for field-testing and commissioning inspections and tests of major electrical upgrades /installations to assure accurate electrical power system and component testing, reporting, and recommendations.

Section 3.1 of the ANSI/NETA ATS and ANSI/NETA ECS should be consulted along with considering the project requirements as related to the credentials of the electrical testing/commissioning firm.

3.16.2. Qualified Electrical Testing Personnel

Qualified electrical testing technicians certified in accordance with ANSI/NETA ETT or OEM certified technicians should be specified when performing the visual, mechanical, and electrical tests and inspections. Section 3.2 of these standards should be consulted when considering project requirements as related to the qualifications of field testing and commissioning personnel.

3.16.3. Safety, Suitability of Test Equipment and Documentation

When specifying project requirements for safety and precautions, suitability of test equipment, test instrument calibration, and test reports, Section 5 of the ANSI/NETA ATS, ANSI/NETA ECS, should be consulted and referenced.

3.16.4. Power system Studies and Electrical Commissioning Process

When specifying power system studies such as short-circuit, coordination, arc-flash hazard analysis, load-flow, stability, and harmonic- analysis, Section 6 of the ANSI/NETA ATS should be referenced. When designing commissioning specifications for electrical power systems, section 6 of the ANSI/NETA ECS should be consulted and referenced regarding commissioning intent, project requirements, basis of design, and the commissioning plan.

3.16.5. Visual, Mechanical and Electrical Equipment Inspections/Tests and Inspection/Commissioning Procedures

When specifying necessary visual, mechanical, and electrical inspections, tests, and results for electrical acceptance and electrical commissioning of electrical power generation and distribution equipment and systems, Section 7 of the ANSI/NETA ATS ANSI/NETA ECS should be consulted and referenced.

3.16.6. Visual, Mechanical and Electrical Equipment Inspections/Tests for Routine and Preventative Maintenance

When specifying necessary visual, mechanical, and electrical inspections, tests, and results for routine and preventive maintenance of electrical power generation and distribution equipment and systems, Section 7 of the ANSI/NETA MTS should be consulted and referenced.

Appendix A – Lighting Metrics/Measurements

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
Interior				
	Conference Rooms			
		Type	Ceiling type dependent	Open Interpretation
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	20:1	
		Color Rendering Index (CRI)	>=80	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	Occupancy sensors	Dual tech - PIR/Ultrasonic
	Lab			
		Type	Ceiling type dependent	Open Ceiling: Linear Pendant LED Luminaire, Frosted Acrylic Lens, White Housing Grid Ceiling: Recessed Mount 2x4 or 2x2 LED Troffer, Luminous Shielding, Center basket design, Die-Formed cold rolled steel, white powder coat finish.
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	10:1	
		Color Rendering Index (CRI)	>=90	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	Manual	
	Office			
		Type		Recessed Mount 2x4 or 2x2 LED Troffer, Luminous Shielding, Center basket design, Die-Formed cold rolled steel, white powder coat finish.
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
		Uniformity	20:1	
		Color Rendering Index (CRI)	>=80	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	Occupancy sensors	Dual tech - PIR/Ultrasonic
	Open Areas/Public Corridors			
		Type	Ceiling type dependent	Hallways: Recessed Mount 2x4 or 2x2 LED Troffer, Luminous Shielding, Center basket design, Die-Formed cold rolled steel, white powder coat finish.
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	40:1	
		Color Rendering Index (CRI)	>=80	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	- - - - -	Through BAS w/ 50% evening reduction.
	Mechanical/Electrical Rooms			
		Type	Strip Fixture	Pendant or surface.
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	40:1	
		Color Rendering Index (CRI)	>=80	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	Manual	
	IT/Security Rooms			
		Type	Strip Fixture	Pendant or surface.
		Technology	LED	

CHAPTER 6: ELECTRICAL ENGINEERING

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	40:1	
		Color Rendering Index (CRI)	>=80	
		Illuminance	- - - - -	Per IECC recommendations.
		Power Density	- - - - -	
		Controls	Occupancy sensors	Dual tech - PIR/Ultrasonic
Exterior				
	Parking Lots			
		Type	Area Luminaire	Low profile, cast aluminum howsing, integral LED driver
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	10:1 Maximum	
		Color Rendering Index (CRI)	>=80	
		Illuminance	See notes	Refer to Boulder Dark Sky Ordinance
		Power Density	- - - - -	
		Controls	Time/Photo setback	
		Light Trespass	BUG/Boulder Dark Sky	
	Parking Structures			
		Type	Area Dependent	
		Technology	LED	
		Correlated Color Temperature (CCT)	4000K	
		Uniformity	10:1 Maximum	
		Color Rendering Index (CRI)	>=80	
		Illuminance	See notes	Refer to Boulder Dark Sky Ordinance
		Power Density	- - - - -	
		Controls	Time/Photo setback	
		Light Trespass	BUG/Boulder Dark Sky	

Appendix B – Power Metrics/Measurements

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
Interior				
	Conference Rooms			
		# of Receptacles	>=4	Coordinate w/ NIST COR
		# of Voice/Data outlets	>=2 faceplates / 4 jacks per faceplate	Coordinate w/ NIST COR
		Wiring Methods	See notes	2-3/4" wireway. 1 each for power and data.
	Lab			
		# of Receptacles	>=4 Every 3 feet along counter or work bench space	Coordinate w/ NIST COR
		# of Voice/Data outlets	>=2 faceplates / 4 jacks per faceplate (Every 6 feet along counter or work bench space)	Coordinate w/ NIST COR
		Wiring Methods	See notes	2-3/4" wireway. 1 each for power and data.
	Office			
		# of Receptacles	4	1 per wall
		# of Voice/Data outlets	2 faceplates / 4 jacks per faceplate	outlets opposite entrance door
		Wiring Methods	See notes	2-3/4" wireway. 1 each for power and data.
	Open Areas			
		# of Receptacles	See notes	Accommodate spacing based on 25' extension cord.
		# of Voice/Data outlets	None	None
		Wiring Methods	See notes	Conduit/wire
	I.T. Closet			
		# of Receptacles	4 + equipment 2 per rack section	1 per wall plus equipment requirements. 2 per rack section, mounted at top/bottom of rack space. Coordinate type and location with COR.

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
		# of Voice/Data outlets	n/a	
		Wiring Methods		Conduit/wire
Exterior				
	Parking Lots			
		# of Receptacles	See notes	Install receptacle on every other pole base.
		# of Voice/Data outlets	None	None
		Wiring Methods	See notes	Conduit/wire
	Parking Structures			
		# of Receptacles	See notes	See specific design criteria.
		# of Voice/Data outlets	None	None
		Wiring Methods	See notes	Conduit/wire
General				
	Cabling / Wiring			
		Insulation	See notes	MV - EPR preferred, TR-XLPE alternate
		Terminations	See notes	MV - cold shrink/heat shrink both acceptable
		Testing	See notes	MV - DC HiPot ok for new installations, VLF HiPot for existing installations
	Building Automation Systems (BAS)			Refer to BAS section in Mechanical Engineering
	Electrical Distribution			
	Switchgear			
		Min. Size	1600A	
		Over Current Protective Devices	Circuit Breakers Only	Low Voltage Power Circuit Breakers

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
		Trip Units	Solid State	
		Arc Flash	Maintenance Switch	For all circuit breakers
	Switchboards			
		Min. Size	600A	
		Over Current Protective Devices	Circuit Breakers Only	Molded Case/Insulated Case
		Trip Units	Solid State	
		Construction	Segregation	Mains/feeders must be in separate enclosures
		Arc Flash	Maintenance Switch	For all circuit breakers
	MCCs			
		Over Current Protective Devices	Circuit Breakers or Fuses	If MCPs, overloads are required.
		Min. Size	400A	
		Controls	120V	
		Arc Flash	Construction	Automatic shutters, section by section segregation
	Distribution Panelboards			
		Over Current Protective Devices	Circuit Breakers Only	Molded Case
		Min. Size	225A	
	Panelboards			
		Over Current Protective Devices	Circuit Breakers Only	Molded Case
		Min. Size	100A	No Load Centers
	Bus Duct / Feeder Bus			
		Min. Size	1600A	Used for feeders 1600A and above
	Transformers			
		Efficiency	10 CFR 431 Part 196	
		Impedance	See notes	Manufacturer standard unless otherwise specified.

CHAPTER 6: ELECTRICAL ENGINEERING

Area	Sub-Area/System	Attribute	Metric/Measurement	Notes
		Insulating Medium	Bio-based	
	Generators*			
	*Programmatic per space	Excitation	PMG	
		Fuel	Natural Gas or Diesel	Depends on application
		Fuel Capacity	24-hour run-time at full load minimum	Coord. w/ NIST COR. If generator serves User equipment, run-time may be longer.
		Noise pollution	Critical silencer/enclosure	
	Lightning Protection			
		All buildings over XXX size		
	Surge Protection			
		Protection Locations	All Service Entrance Mains	
		Surge Capacity	250kA	
	UPS			
	*Programmatic per space	Technology	Line Interactive Only	
		Efficiency	Double conversion >=94%	
		Power Electronics	IGBT	
		Batteries	Li-ion or lead acid	

NIST – Color Chart

Conduit Color Chart	Label Color Chart	Wiring Device Color
Normal Power Branch – Grey	Grey w/ white letters	Grey
Emergency Life Safety Branch – Yellow	Yellow w/ black letters	Yellow
Normal Power Research Branch – White	White w/ black letters	White
UPS/Generator Research Branch – Black	Black w/ white letters	Black
Emergency Telecomm Branch – Orange	Brown w/ white letters	Orange
Emergency Equipment Branch – Green	Green w/ white letters	Green
Mechanical Controls – Blue	Blue w/ white letters	Blue
Fire Alarm/VESDA - Red	Red w/ white letters	Red
Security – Purple	Purple w/ white letters	n/a

Note: “Branch” means entire path from main switchboard down to branch circuit device.

Electrical Naming Convention – rev4

Equipment	Maximo ID	Label
Switchgear	B##-SWGR-####-##	SWGR-##-####
Switchboard	B##-SWBD-####-##	SWBD-####-##
Motor Control Center	B##-MCC-####-##	MCC-####-##
Power Distribution Panel (e.g. I-Line or Pow-R-Line 4B styles)	B##-PDP-####-##	PDP-####-##
Branch Distribution Panel	B##-PNL-####-##	PNL-####-##
Transformer	B##-XMR-####-##(#)	XMR-####-##(#)
	The third digit in the second grouping is meant for service entrance transformers only, e.g. XMR-001.	
Bus Duct	B##-BD-####-##	BD-####-##
Feeder Bus	B##-FB-####-##	FB-####-##
VFDs	B##-VFD-####-##	VFD-####-##
UPS	B##-UPS-####-##	UPS-####-##
Generator	B##-EMG-####-##	EMG-####-##
Automatic Transfer Switch	B##-ATS-####-##	ATS-####-##
Disconnect (CB or fused switch)	B##-DS-####-##	DS-####-##
Network Protector	B##-NP-####-##	NP-####-##
	The last "##" digits refer to the transformer #, from which the NP is fed. For example: NP-073 is the network protector fed from XMR-073. If the NP is in a room, e.g. NP-1065-001.	
Pad Mounted Switch	BOULDER-PMS-##-##	PMS-##-##
	Named w/ associated man-hole. E.g. PMS-15-01 would be pad mount switch on man hole 15, switch #1, or PMS-1A-01 is pad mount switch on mand hole 1A, switch #1.	
Air Switch	B##-AS-####-##	AS-####-##
High Speed Switch	BOULDER-HSS-##	HSS-##
Man Hole	BOULDER-MH-##	MH-##

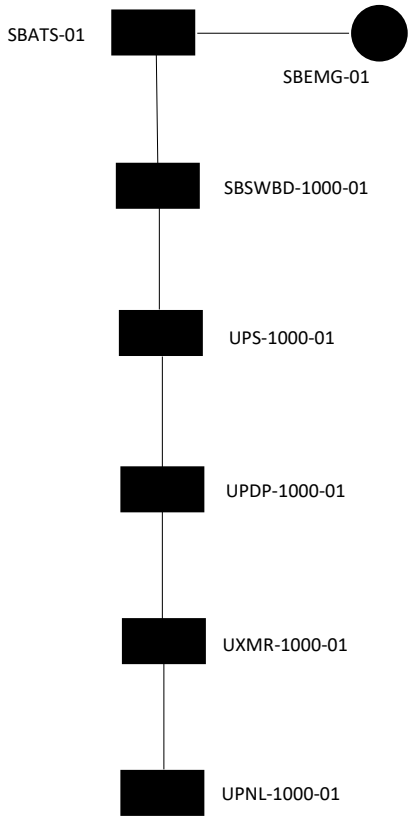
B## - Denotes Building number numeric. #### - Denotes room/column line. ##- Denotes numeric (in some cases, this could denote a numeric/alpha character, e.g. MH-1A).

Notes:

- Use a numeric to identify equipment, e.g. SWGR-#####-**01**, XMR-#####-**05**, etc.
- Two general naming conventions for indoor or outdoor equipment:
    - Indoor equipment shall have an additional identifier added to the middle of the equipment name, designating the room where the equipment is installed, e.g. SWGR-**2K111**-01.
        - If the equipment is installed in a hallway, corridor (with no hallway or corr #) or non-descript room, utilize the nearest column designations, e.g. PNL-**A15**-01.
    - Primary voltage rated outdoor equipment (13.2kV) will have no identifier after its numeric name, e.g. HSS-**01**.

- Outdoor equipment rated at utilization voltage levels (600V and below) will be identified by the designator “B##X”. For example, a 15 kVA dry type transformer, located outside of B02 would be designated as XMR-**02X**-01.

- Recommend adding an “SB” for emergency or standby power in front of a given equipment identifier. For example: **SB**SWGR-1800-01, **SB**PDP-1800-01, **SB**ATS-01, etc.
- For life safety, utilize “LS”, e.g. **LS**PNL-1000-01, **LS**ATS-1000-01, etc.
- Utilize a “M” designator for mechanical loads.
- Utilize “IT” for IT designated loads.
- Utilize “U” for UPS loads.
- Distinction shall be made for those systems that are on standby power and have a stationary UPS system. For example:



Those items including the generator, ATS, downstream equipment off of the ATS but before a UPS, shall use “SB” designators.
Those items downstream of the UPS shall have “U” designators.
If there was no UPS in the system, the system naming would comprise of all “SB” designators.

- An example of a full Maximo technical ID would be: 01-SBSWGR-1000-01, 01C-SWGR-1000-01, 02-PDP-1000-01. Even if room #'s duplicate between buildings which could possibly result in duplicate equipment names, Maximo will have unique identifiers, as the building # is a part of the Maximo asset name.
- Outdoor equipment which services a given building, will still receive a building numeric in its Maximo technical ID, e.g. 12-XMR-052 is the outdoor, padmount transformer that serves Bldg. 12.
- With regards to feeder bus and bus duct naming. The name of the run will be dependent on where the feeder/bus duct receives its electrical feed. For example, if the bus duct, cable tap box is installed in room 1000, then the asset name would be: BD-1000-01, regardless if the entire run spans a number of rooms or floors.
- Not all Equipment entered into Maximo will receive a job plan.
- We will have to be diligent about maintaining unique numeric names for outside/indoor service entrance transformers. Since the site MV one line has all of the service entrance transformers on the drawing, it could get confusing if there were duplicate names on one drawing.
- "BOULDER" is used in the Maximo asset name to identify outdoor equipment that does not service one area. Pad mount switches, man holes and high-speed switches will use this descriptor.
- Use no more than two designators for a given piece of equipment. For example, a mechanical panel on standby could be identified as SBMPDP-1000-01 beginning with the upstream electrical system and then finally the connected load. UITPNL-1000-01 would be used for IT equipment on the standby generator/UPS system.
- Main-Tie-Main switchgear configurations shall be named as -01 & -02. For example: SWGR-2000-01 & SWGR-2000-02. For those switchgear configurations that have no tie, but have dual mains, only use one designator, e.g. SWGR-3000-01.

UPDP-1000-01

480/277V, 3ph, 4W, 600A

Fed from UPS-1000-01

Example of a power distribution panel (for a lab area) on UPS.

PNL-1000-01

208/120V, 3ph, 4W, 100A

Fed from XMR-1000-01

Example of a branch circuit panelboard on “house” power.

- Label standard: 5”H x 7”L, phenolic style labels. Colors as indicated below:

Conduit Color Chart	Label Color Chart	Wiring Device Color
Normal Power Branch – Grey	Grey w/ white letters	Grey
Emergency Life Safety Branch – Yellow	Yellow w/ black letters	Yellow
Normal Power Research Branch – White	White w/ black letters	White
UPS/Generator Research Branch – Black	Black w/ white letters	Black
Emergency Telecomm Branch – Orange	Brown w/ white letters	Orange
Emergency Equipment Branch – Green	Green w/ white letters	Green
Mechanical Controls – Blue	Blue w/ white letters	Blue
Fire Alarm/VESDA - Red	Red w/ white letters	Red
Security – Purple	Purple w/ white letters	n/a

Commented [PMP(1]: UPS/Generator?

- A 3”H x 5”L label is acceptable for smaller load center, branch circuit panelboards.

Certificate of Occupancy Requirements

For NIST to take possession of a building/receive the official Certificate of Occupancy (CO), the following inspections/final tests shall be performed and accepted by NIST prior to the project's contract completion date:

- Lightning Protection – Contractor shall submit the Master Label to NIST OFPM.

- Safety Inspection – The NIST AHJ and Safety Groups will walk the facility to identify any safety hazards. This walk shall occur around/at the same time as the final punch. All the items identified by the AHJ/Safety Groups shall be addressed/corrected to receive the CO.

- Fire Alarm/Fire Suppression Final Tests – The fire alarm and fire suppression systems shall work properly. NIST OFPM and NIST AHJ will witness the tests. The fire alarm fiber optic cable shall be installed/tested and connected to the new FACP prior to these final tests.

- Generator Final Test – The generator and associated transfer switches shall work properly. NIST OFPM and NIST AHJ will witness this test. All devices/systems (exterior and interior egress lighting, cooling, fire alarm, security, IT, etc.) fed from the generator shall work properly once they are switched over to back-up power.

- UPS – The UPS shall work properly. NIST OFPM will witness this test. All devices fed from the UPS shall work properly once they are switched over to UPS power.

- IT – All of the MDF and IDF Rooms shall have operational lighting, power, cooling, and access controls. All the IT networking equipment and associated cabling shall be installed and be operational. NIST needs to receive the CommScope warranty that ensures all the cabling has been installed correctly and tested. NIST OFPM and OISM shall perform acceptance walk of these spaces.

- Physical Security (Keypads and Intrusion Detection) Final Test – All of the Security Rooms shall have operational lighting, power, cooling, and access controls. All devices in this system, associated door hardware shall work properly. All control panels shall be connected to the Physical Security networking equipment and be visible at NIST Dispatch. NIST OFPM, ESO, and OISM shall witness the final test.

- Security Camera Final Test - All devices in this system shall work properly. All equipment shall be connected to the camera networking equipment be visible at NIST Dispatch. NIST OFPM, ESO, and OISM shall witness the final test.

- Mechanical Equipment/Mechanical Controls – All the mechanical equipment, associated controls, and networking equipment shall work properly. Contractor shall troubleshoot all Metasys alarms prior to connecting it to the NIST network. This is accomplished by the contractor installing a temporary network to link all the control panels together during Cx. NIST OFPM shall witness this.

- Architectural – All building elements (exterior and interior) including finishes are completed per contract. This includes water testing at roof, glazing, and curtain wall systems that have passed. Elevator(s) are working properly and the camera(s) within the elevator cab(s) are functioning properly and NIST is able to view the cab interior. NIST shall witness these tests.