Addendum 01
SFISD RJ Wollam Elementary School
& Santa Fe Junior High School
Generator Installation

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cre8 ARCHITECTS

8 April 2022

This addendum modifies the original Proposal Documents dated March 25, 2022 and forms a part of the Contract Documents. Acknowledge receipt of this Addendum in the space provided on the Proposal Form. Failure to do so may subject Proposer to disqualification.

This Addendum consists of 62 pages.
**The time and date to receive Proposals is unchanged by this Addendum**

## 1.0 CHANGES TO PROCUREMENT AND CONTRACTING REQUIREMENTS:

01 Section 00 11 10 REQUEST FOR COMPETITIVE SEALED PROPOSALS
Paragraph 1.04 Preproposal Meeting – Change Date and Time as follows:
1. *Date: Thursday, April 14, 2022*
2. *Time: 9:30 AM*

## 2.0 CHANGES TO SPECIFICATIONS:

01 Section 01 50 00 TEMPORARY FACILITIES AND CONTROLS
Paragraph 2.02 Temporary Facilities
Delete the following subparagraphs:
A. Field Office, General
B. Common-Use Field Office

02 Section 00 79 00 DEMONSTSRATION AND TRAINING
*Delete all requirements for demonstration and training video recordings from this specification section.*

03 Replace Section 26 00 00 – Common Electrical Requirements:
A. Modified paragraph 1.34.H. regarding the requirement to seal watertight any sleeve or conduit penetrating an exterior building wall.

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B. Modified paragraph 1.40.A. to reduce the period of time to provide skilled labor and helpers for operational instruction.

04 Replace Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables:
A. Added paragraph 3.03.G. to clarify existing branch circuits that are being relocated to a new panel and requirements to upsize conductors or measure voltage drop.
B. Added paragraph 3.03.K. to provide requirements for conduit fill and conductor derating on existing circuits that are being relocated.

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05 Replace Section 26 05 26 – Grounding and Bonding
A. Modified paragraph 3.07.A. regarding where separate equipment grounding conductors will be required.
B. Deleted paragraph 3.09.A.1. to remove requirement for a manufacturer's field service representative.

06 Replace Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
A. Modified paragraph 3.02.C. and added paragraph 3.02.D. to clarify where concrete encasement of electrical ductbanks will be required.

07 Replace Section 26 05 53 – Identification for Electrical Systems
A. Deleted paragraph 3.02.K. Panelboard Naming Convention Sign.
B. Modified paragraph 3.02.L. to apply only to electrical rooms that have work included in the project scope.

08 Replace Section 26 05 73 – Overcurrent Protective Device Studies
A. Added paragraph 1.01.B. to clarify which panels and equipment are to be included in these studies.

09 Replace Section 26 22 00 – Low-Voltage Transformers
A. Deleted paragraph 3.06.A.1. to remove requirement for a manufacturer's field service representative.

10 Replace Section 26 24 16 – Panelboards
A. Deleted paragraph 3.05.A.1. to remove requirement for a manufacturer's field service representative.

11 Replace Section 26 43 13 – SPD for Low-Voltage Electrical Power Circuits
A. Deleted paragraphs 3.02.A.1. and 3.02.B.1. to remove requirement for a manufacturer's field service representative.

**3.0 CHANGES TO DRAWINGS:**

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01 Replace Sheet JH-E4.0 –Enlarged Electrical Plan - Generator:

A. Re-arranged location of transformers and panelboards in new electrical room to meet required NEC clearances.

END OF ADDENDUM 01

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SECTION 26 00 00 - COMMON ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes common requirements for the entire project.

1.02 GENERAL

A. The Instructions to Bidders, General and Special Conditions, and all other contract documents shall apply to the Contractor's work as well as to each of his Sub-Contractor's work. Each Contractor is directed to familiarize himself in detail with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.

B. Each Contractor shall be governed by any alternates, unit prices and addenda or other contract documents insofar as may affect the work or services.

C. The work included in this division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material and appurtenances and performing all operations necessary for the satisfactory installation of the complete and operating Electrical System(s) indicated and/or specified in the Contract Documents.

D. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.

E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting his bid, it shall be understood that the Contractor has included the cost of all required items in his bid, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensation.

F. It is not the intent of this section of the specifications (or the remainder of the contract documents) to make any specific Contractor, other than the Contractor holding the prime agreement, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Contractor to the Architect (if applicable), then to the Engineer.

G. This section of the Specifications or the arrangement of the Contract Documents shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular Contractor or Sub-Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

H. It is the intent of this Contract to deliver to the Owner a new and complete project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

I. In general, and to the extent possible, all work shall be accomplished without interruption of facility operations. The Contractor shall advise the Architect, Owner and Engineer in writing at least one week prior to the deliberate interruption of any services. The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage by the Contractors involved until a complete schedule of interruptions can be developed.

J. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of his own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation to the Owner, except where otherwise provided for in the contract for the work.

1.03 DEFINITIONS

A. Architect: The Architect of Record for the project, if any.

B. Contract Documents: All documents pertinent to the quality and quantity of all work to be performed on the project. Includes, but not limited to, plans, specifications, addenda, instructions to bidders (both General and Sub-Contractors), unit prices, shop drawings, field orders, change orders, cost breakdowns, construction manager's assignments, architect's supplemental instructions, periodical payment requests, etc.

1. Note: Any reference within these specifications to a specific entity, i.e. "Electrical Contractor" is not to be construed as an attempt to limit or define the scope of work for that entity or assign work to a specific trade or contracting entity. Such assignments of responsibility are the responsibility of the Contractor or Construction Manager holding the prime contract, unless otherwise provided herein.

C. Contractor: Any Contractor whether proposing or working independently or under the supervision of a General Contractor and/or Construction Manager and who installs any type of electrical work (Electrical, Low Voltage, Fire Alarm, etc.) or, the General Contractor.

D. Engineer: The Consulting Mechanical-Electrical Engineers either consulting to the Owner, Architect, other Engineers, etc.

E. Furnish: Deliver to the site in good condition.
F. Install: Install equipment furnished by others in complete working order.
G. Provide: Furnish and install in complete working order.

1.04 INTENT

A. It is the intention of the Contract Documents to provide finished work, tested and ready for operation.
B. Minor details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

1.05 DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed insofar as possible. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Contract Drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Contractor shall anticipate that additional offsets may be required without additional cost to the Owner and submit their bid accordingly.
B. The drawings and specifications are intended to supplement each other. No Contractor shall take advantage of conflict between them, or between parts of either. This also includes potential conflicts with regards to equipment and material model numbers, part numbers, etc. and respective description and/or performance. Should this condition exist, the Contractor shall request a clarification not less than 10 days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be the determining factor. In all instances, unless modified in writing and agreed upon by all parties thereto, the Contract to accomplish the work shall be binding on the affected Contractor.
C. The drawings and specifications shall be considered to be cooperative and complimentary and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
D. Contractor shall make all necessary and required measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.
E. The Engineer shall reserve the right to make adjustments in location of conduit, fixtures, outlets, switches, etc. where such adjustments are in the interest of concealing work or presenting a better appearance. Unless a formal proposal request is issued, this work shall be performed without additional cost to the Owner.
F. Each Contractor shall evaluate ceiling heights called for on Architectural Plans. Where the location of Electrical equipment may interfere with ceiling heights, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work on the part of the Contractor or unduly delay the work.
G. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
H. The Electrical drawings are intended to show the approximate locations of equipment, materials, conduit, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to ensure no conflict with other work. In case of conflict between small and large scale drawings, the larger scale drawings shall take precedence.
I. The Electrical Contractor and his Sub-Contractors shall review all construction documents in detail as they may relate to his work (structural, architectural, site survey, mechanical, etc.). Review all drawings for general coordination of work, responsibilities, ceiling clearances, wall penetrations points, chase access, fixture elevations, etc. Make any pertinent coordination or apparent conflict comments to the Engineer at least ten days prior to bids, for issuance of clarification by written addendum.
J. The Electrical Contractor and his Sub-Contractors shall ensure there is adequate space to install the equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the proposer and shall be accomplished fully without additional expense to the Owner and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to ensure adequate spaces.
K. Where on the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
L. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work without additional cost to the Owner, the same as if herein specified or indicated.
M. Where on the Drawings or Addenda the word typical is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

N. Always check ceiling heights indicated on Architectural Documents and ensure they can be installed appropriately and that they may be maintained after all mechanical and electrical equipment is installed. If a conflict is apparent, notify the Engineer in writing for instructions. Do not install equipment in the affected area until the conflict is resolved.

1.06 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS

A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc.

B. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any drawings, specifications, diagram, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense.

C. Review of shop drawings, submittals, etc. by the Engineer does not in any way absolve the Contractor of the responsibilities of equipment and materials substitutions or deviations.

D. Even with any reference in the specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the preceding provisions are met.

E. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.

F. Each Contractor shall furnish along with the proposal a list of requested equipment and materials which is to be provided. Where several makes are mentioned in the specifications and the Contractor fails to state which they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineers will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

G. Each Contractor shall give written notice to the Architect/Engineer 5 days prior to the submission of a proposal of any materials or apparatus believed inadequate or unsuitable; in violation of codes, laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted. In the absence of such written notice, Proposers signify that they have included the cost of all required items in the proposal and that the Proposer will be responsible for the safe and satisfactory operation of the entire system without additional cost to the Owner.

1.07 COST BREAKDOWNS

A. Within thirty days after acceptance of the Contract, each Contractor is required to furnish to the Engineer one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made on forms provided or approved by the Engineer or Architect. Payments will not be made until satisfactory cost breakdowns are submitted.

1.08 GUARANTEES AND WARRANTIES

A. Items of equipment which have longer guarantees, as called for in these specifications or as otherwise offered by the manufacturer, such as lighting, generators, engines, batteries, transformers, etc., shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of submittal and at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall in no way invalidate the guarantee except that Owner shall be liable for any damage to equipment during this period due to negligence of his operator or other employee.

1.09 RECORD DRAWINGS

A. The Contractor shall ensure that any deviations from the design are being recorded daily or as necessary on record drawings being maintained by the Contractor. Dimensions from fixed, visible permanent lines or landmarks shown in vertical and horizontal ways shall be utilized. Compliance shall be a requirement for final payment. Pay particular attention to the location of underfloor or underground exterior in-contract or utility-owned or leased service lines, main switches and other appurtenances important to the maintenance and safety of the Electrical System. Deliver these record drawings to the Engineer as a system is completed, within ten days of the mark-up and/or while the accuracy of the mark-ups can be verified visually. Monthly payment may be withheld if the requirement is not complied with.

1.10 EXAMINATION OF SITE AND CONDITIONS

A. Each Contractor shall be responsible for the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.

B. Each Contractor shall carefully examine all Drawings and Specifications and inform themselves of the kind and type of materials to be used throughout the project and which may, in any way, affect the execution of his work

C. Each Contractor shall fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of temporary or permanent utilities,

etc. The Contractor shall include in his work all expenses or disbursements in connection with such matters and conditions. Each Contractor shall verify all work shown on the drawings and conditions at the site, and shall report in writing to the Engineer ten days prior to bid, any apparent omissions or discrepancies in order that clarifications may be issued by written addendum. No allowance is to be made for lack of knowledge concerning such conditions after bids are accepted.

1.11 SURVEYS, MEASUREMENTS AND GRADES

A. Contractor shall lay out his work and be responsible for all necessary lines, levels, elevations and measurements. He must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from his failure to do so.

B. Contractor shall base all measurements, both horizontal and vertical from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, he shall notify the Engineer thru normal channels of job communication and shall not proceed with his work until he has received instructions from the Engineer.

1.12 QUALIFICATIONS OF WORKMEN

A. The installation of all Electrical Work shall be performed by licensed electricians and in accordance with current State Law. All Electrical Contractors bidding this project must have been a licensed company for a minimum of three years to qualify to bid this project. Individual employee experience does not supersede this requirement.

B. All subcontractors bidding the electrical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.

C. All electrical work shall be accomplished by qualified workmen competent in the area of work for which they are responsible. Untrained and incompetent workmen as evidenced by their workmanship shall be relieved of their responsibilities in those areas. The Engineer shall reserve the right to determine the quality of workmanship of any workman and unqualified or incompetent workmen shall refrain from work in areas not satisfactory to him. Requests for relief of a workman shall be made through the normal channels of responsibility established by the Architect or the contract document provisions.

D. All electrical work shall be accomplished by Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

E. Special electrical systems, such as Fire Detection and Alarm Systems, Intercom or Sound Reinforcement Systems, Telecommunications or Data Systems, Lightning Protection Systems, Video Systems, Special Electronic Systems, Control Systems, etc., shall be installed by workmen normally engaged or employed in these respective trades. As an exception to this, where small amounts of such work are required and are, in the opinion of the Engineer, within the competency of workmen directly employed by the Contractor involved, they may be provided by this Contractor.

1.13 CONDUCT OF WORKMEN

A. The Contractor shall be responsible for the conduct of all workmen under his supervision. Misconduct on the part of any workmen to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt permanent dismissal of that workman from the project. The possession, consumption or influence of alcoholic beverages, narcotics or illegally used controlled substances on the jobsite is strictly forbidden. Possession of a fire-arm is prohibited and may result in prosecution. Foul or bad language, graffiti is strictly prohibited. Display of nude tattoos is prohibited.

1.14 SUPERVISION OF WORK

A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineers, on the work at all times during progress with full authority to act on behalf of the Contractor.

1.15 MATERIALS AND WORKMANSHIP

A. All electrical equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. All workmanship shall be first-class and shall be performed by electricians skilled and regularly employed in their respective trades. The Contractor shall determine that the equipment he proposes to furnish can be brought into the building(s) and installed within the space available. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s).

B. All conduit and/or conductors shall be concealed underground, within crawl space in or below walls, floors or above ceilings unless otherwise noted. All fixtures, devices and wiring required shall be installed to make up complete systems as indicated on the drawings and specified herein. Raceways shall not be placed within foundation walls and footings. See notes on plans about the limitation on work allowed to be installed within the crawl space.

C. All materials, where applicable, shall bear Underwriters' Laboratories label or that of another Engineer-approved testing agency, where such a standard has been established.

D. Each length of conduit, wireway, duct, conductor, cable, fitting, fixture and device used in the electrical systems shall be stamped or indelibly marked with the maker's mark or name.
E. All electrical equipment shall bear the manufacturer's name and address and shall indicate its electrical capacity and characteristics.
F. All electrical materials, equipment and appliances shall conform to the latest standards of the National Electric Manufacturers Association (NEMA) and the National Board of Fire Underwriters (NBFU) and shall be approved by the Owner's insuring agency if so required.

1.16 COOPERATION AND COORDINATION WITH OTHER TRADES

A. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to his work, including Architectural, Plumbing, Fire Protection, Mechanical and Structural Drawings, to the end that complete coordination between trades will be affected. Each Contractor shall make know to all other contractors the intended positioning of materials, raceways, supports, equipment and the intended order of his work. Coordinate all work with other trades and proceed with the installation in a manner that will not create delays for other trades or affect the Owner's operations.
B. Special attention to coordination shall be given to points where raceways, fixtures, etc., must cross other ducts or conduit, where lighting fixtures must be recessed in ceilings, and where fixtures, conduit and devices must recess into walls, soffits, columns, etc. It shall be the responsibility of each Contractor to leave the necessary room for other trades. No extra compensation or time will be allowed to cover the cost of removing fixtures, devices, conduit, ducts, etc. or equipment found encroaching on space required by others.
C. The Contractor shall be responsible for coordination with all trades to ensure they have made provisions for connections, operational switches, disconnect switches, fused disconnects, etc., for electrically operated equipment provided under this or any other division of the specifications, or as called for on the drawings. Any connection, circuiting, disconnects, fuses, etc., that are required for equipment operation shall be provided as a part of this contract.
D. If any discrepancies occur between accompanying drawings and these specifications and drawings and specifications covering other trade's work, each trade shall report such discrepancies to the Engineer far enough in advance so that a workable solution can be presented. No extra payment will be allowed for relocation of fixtures, devices, conduit, and equipment not installed or connected in accordance with the above instructions.
E. In all areas where air diffusers, devices, luminaires and other ceiling-mounted devices are to be installed, the Mechanical Trade(s) and the Electrical Trade and the General Trades shall coordinate their respective construction and installations so as to provide a combined symmetrical arrangement that is acceptable to the Engineer. Where applicable, refer to reflected ceiling plans. Request layouts from the Engineer where in doubt about the potential acceptability of an installation.

1.17 INTERFACING

A. Each Electrical Trade, Specialty Controls Trade, Mechanical Trade and the General Trades, etc., shall ensure that coordination is affected relative to interfacing of all systems. Some typical interface points are (but not necessarily all):

1. Connection of Telecommunications (voice, video, data) lines to Owner's existing or new services.
2. Connection of Power lines to Owner's existing or new services.
3. Connection of all controls to equipment.
4. Electrical power connections to electrically operated (or controlled) equipment.
5. Electrical provisions for all equipment provided by other trades or suppliers within this contract.

1.18 CONNECTION TO EQUIPMENT FURNISHED BY OTHERS

A. Each Contractor shall make all connections to equipment furnished by others, whenever such equipment is shown on any part of the drawings or mentioned in any part of the Specifications, unless otherwise specifically specified hereinafter.
B. All drawings are complementary, one trade of the other. It is the Contractor's responsibility to examine all drawings and specifications to determine the full scope of his work. The project Engineers have arranged the specifications and drawings in their given order solely as a convenience in organizing the project, and in no way shall they imply the assignment of work to specific trades, contractors, subcontractors or suppliers.
C. Supervision to assure proper installation, functioning and operation shall be provided by the Contractor furnishing the equipment or apparatus to be connected.
D. Items indicated on the drawings as rough-in only (RIO) will be connected by the equipment supplier or Owner, as indicated. The Contractor shall be responsible for rough-in provisions only as indicated. These rough-ins shall be in accord with the manufacturer's or supplier's requirements.
E. For items furnished by others, relocated, or RIO, the Contractor shall obtain from the supplier or shall field determine as appropriate, the exact rough-in locations and connection sizes for the referenced equipment.
F. The Contractor shall be responsible for coordinating with the General and all other trades, as necessary, to determine any and all final connections that he is to make to equipment furnished by others.

1.19 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.

A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, extensions, etc. in connection with his work.

B. The Contractor shall file all necessary plans, utility easement requests and drawings, survey information on line locations, load calculations, etc. prepare all documents and obtain all necessary approvals of all utility and governmental departments having jurisdiction; obtain all certificates of inspection for his work and deliver same to the Engineer before request for acceptance and final payment for the work.

C. Ignorance of Codes, Rules, Regulations, Laws, etc. shall not render the Contractor irresponsible for compliance. The Contractor shall be versed in all Codes, Rules and Regulations pertinent to the work prior to submission of a proposal.

D. The Contractor shall include in the work, without extra cost, any labor, materials, services, apparatus and drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.

E. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

F. All materials and equipment shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

G. Where minimum code requirements are exceeded in the Design, the Design shall govern.

H. The Contractor shall ensure that the work is accomplished in accordance with the OSHA Standards and any other applicable government requirements.

I. All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction.

J. Where conflict arises between any code and the plans and/or specifications, the code shall apply except in the instance where the plans and specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten working days prior to bid date, otherwise the Contractor shall make the required changes at his own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the drawings and specifications require better materials, equipment, and construction than these minimum standards, in which case the drawings and specifications shall be the minimum standards.

1.20 TEMPORARY SERVICES

A. The Contractor shall arrange with the General Contractor or Construction Manager for temporary electrical and other services which he may require to accomplish his work. In the absence of other provisions in the contract, the Contractor shall provide for his own temporary services of all types, including the cost of connections, utility company fees, construction, removal, etc., in his bid.

B. All temporary services shall be removed by Contractor prior to acceptance of work.

1.21 TEMPORARY USE OF EQUIPMENT

A. The permanent electrical equipment, when installed, may be used for temporary services, subject to an agreement between the Contractors involved, the Owner, and with the consent of the Engineer. Should the permanent systems be used for this purpose, each Contractor shall pay for all temporary connections required and any replacements required due to damage without cost, leaving the equipment and installation in "as new" condition.

B. Permission to use the permanent equipment does not relieve the Contractors who utilize this equipment from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

1.22 PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be entirely responsible for all material and equipment furnished in connection with the work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All rough-in conduit shall be properly plugged or capped during construction in a manner approved by the Engineer.

B. Equipment damaged, stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced (as determined by the Engineer) by the responsible Contractor. Electrical equipment exposed to the weather shall be replaced by the Contractor at the Contractor’s expense.

1.23 EQUIPMENT SUPPORT

A. Each piece of equipment, apparatus, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, conduit rack, or platform in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and conduit. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc.

1.24 REQUIRED CLEARANCE FOR ELECTRICAL EQUIPMENT

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc.

B. Contractor shall ensure that no piping, ductwork, etc., is installed in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated without additional cost to the Owner.

1.25 ACCESSIBILITY

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in partitions and above suspended ceilings for the proper installation of his work. He shall cooperate with the General Contractor (or Construction Manager) and all other Contractors whose work is in the same space, and shall advise each Contractor of his requirements. Such spaces and clearances shall be kept to the minimum size required to ensure adequate clearance and access.

B. The Contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include but not be limited to junction boxes, pull boxes, contactors, panels, disconnects, controllers, switchgear, etc. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved where the equipment is concealed.

C. Each Contractor shall provide (or arrange for the provision by other trades) the access panels for each concealed junction box, pull box, fixtures or electrical device requiring access or service as shown on Engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. All access panels shall be installed in accord with the Architect's standards for such work.

D. Access Doors; in Ceilings or Walls:

1. In mechanical, electrical, or service spaces:
   a. 14-gauge aluminum, 1" border, refer to architectural specifications for finishes
2. In finished areas:
   a. 14-gauge primed steel with 1" border to accept the architectural finishes specified for the space. Confirm these provisions with the Architect prior to obtaining materials or installing any such work.
3. In fire or smoke rated partitions, access doors shall be provided that equal or exceed the required rating of the construction they are mounted in.
4. All access doors shall have continuous hinge and screw type cover. Openings shall be sized to allow personal to pass through.

E. Sides of cable trays cannot be obstructed by pipes, ductwork, cables, etc.

1.26 MAINTENANCE OF EXISTING UTILITIES AND LINES

A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that come within the contract construction site, shall be subject to continuous uninterrupted maintenance with no exception unless the Owner of the utilities grants permission to interrupt same temporarily, if need be. Provide one week's written notice to Engineer, Architect and Owner prior to interrupting any utility service or line. Also, see Article 1. - General, this section.

B. Known utilities and lines as available to the Engineer are shown on the drawings. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Contractor shall bear costs of repairing damaged utilities.

C. If the above-mentioned utilities or lines occur in the earth within the construction site, the Contractor shall first probe and make every effort to locate the lines prior to excavating in the respective area.

D. Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Engineer any surface or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted within ten feet of existing gas or fuel lines. Hand excavate only in these areas, in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

1.27 RESTORATION OF NEW OR EXISTING SHRUBS, PAVING, ETC.

A. The Contractor shall replace to their original condition all paving, curbing surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item to be replaced. All repairs shall be to the satisfaction of the Engineer, and in accord with the Architect's standards for such work, as applicable. Patchwork on new construction will not be accepted.

1.28 CONCRETE WORK

A. The Contractor shall be responsible for the provision of all concrete work required for the installation of any of his systems or equipment. If this work is provided by another trade, it will not relieve the Electrical Contractor of his responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete specifications, all concrete

related to Electrical work shall be 3000 PSI minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication ACI-318. Heavy equipment shall not be set on pads for at least seven days after pour.

B. All concrete pads shall be complete with all pipe sleeves, embeds, anchor bolts, reinforcing steel, concrete, etc., as required. Pads larger than 18" in width shall be reinforced with minimum #4 round bars on 6" centers both ways. All reinforcing steel shall be per ASTM requirements, tied properly, lapped 18 bar diameters and supported appropriately up off form, slab or underlayment. Bars shall be approximately 3" above the bottom of the pad with a minimum 2" cover. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms properly adhered repairs shall be made. If structural integrity is violated, the concrete shall be replaced. All surfaces shall be rubbed to a smooth finish and chamfered edges.

C. All pads and concrete lighting standard bases shall be crowned slightly in center to avoid water ponding beneath equipment.

D. In general, concrete pads for small equipment shall extend 6" beyond the equipment's base dimensions. For large equipment with service access panels, extend pads 18" beyond base or overall dimensions to allow walking and servicing space at locations requiring service access.

E. Exterior concrete pads shall be 4" minimum above grade and 4" below grade on a tamped 4" dense grade rock base unless otherwise noted or required by utility company. Surfaces of all foundations and bases shall have a smooth finish with three-quarter inch radius or chamfer on exposed edges, troweled or rubbed smooth. All exterior pads shall be crowned approximately 1/8" per foot, sloping from center for drainage.

1.29 FINAL CONNECTIONS TO EQUIPMENT

A. The roughing-in and final connections to all electrically operated equipment furnished under this and all other sections of the contract documents or by others, shall be included in the Contract and shall consist of furnishing all labor and materials for connection and proper testing. The Contractor shall carefully coordinate with equipment suppliers, manufacturer's representatives, the vendor or other trades to provide complete electrical and dimensional interface to all such equipment (kitchen, hoods, mechanical equipment, panels, refrigeration equipment, etc.).

1.30 ELECTRICAL CONNECTIONS

A. The Contractor shall furnish and install all power wiring and fusing complete from power source to motor or equipment junction box, including power wiring through starters. The Contractor shall install all starters not factory mounted on equipment. Unless otherwise noted, the supplier of equipment shall furnish starters with the equipment. Also, refer to Divisions 21, 22, and 23 of Specifications, shop drawings and equipment schedules for additional information.

B. All control, interlock, sensor, thermocouple and other wiring required for equipment operation shall be provided by the Contractor. All such installations shall be fully compliant with all requirements of Division 26 regardless of which trade actually installs such wiring. Motors and equipment shall be provided for current and voltage characteristics as indicated or required. All wiring shall be enclosed in raceways unless otherwise noted.

C. Each Contractor or sub-contractor, prior to bidding the work, shall coordinate power, control, sensor, interlock and all other wiring requirements for equipment or motors with all other contractors or sub-contractors, to ensure all needed wiring is provided in the Contract. Failure to make such coordination shall not be justification for claims of extra cost or a time extension to the Contract.

1.31 MOTORS

A. Each motor shall be provided by the equipment supplier or manufacturer with conduit terminal box, adequate starting and internal thermal overload protective equipment as specified or required. The capacity shall be sufficient to operate associated driven devices under all conditions of operation and load and without overload, and at least of the horsepower indicated or specified. Each motor shall be selected for quiet operation, maximum efficiency and lowest starting KVA per horsepower as applicable. Also, see mechanical specification for further requirements and scheduled sizes.

1.32 QUIET OPERATION, SUPPORTS, VIBRATION AND OSCILLATION

A. All work shall operate under all conditions of load without any objectionable sound or vibration, the performance of which shall be determined by the Engineer. Noise from moving machinery or vibration noticeable outside of room in which it is installed, or annoyingly noticeable noise or vibration inside such room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor (or Contractors responsible) at his expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc., by means of flexible connectors, vibration absorbers or other approved means. Surface mounted equipment such as panels, switches, etc., shall be affixed tightly to their mounting surface.

C. The Contractor shall provide supports for all equipment furnished by him using an approved vibration isolating type as needed. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through

supporting members by means of bolts or equally effective means. No work shall depend on the supports or work of unrelated trades unless specifically authorized in writing by the Architect or Engineer.

1.33 CUTTING AND PATCHING

A. Unless otherwise indicated or specified, each Contractor shall provide his own cutting and patching necessary to install the work specified in this Division. Patching shall match adjacent surfaces to the satisfaction of the Engineer and shall be in accord with the Architect's standards for such work, as applicable.

B. Each Electrical Contractor shall be responsible for all openings, sleeves, trenches, etc. that he may require in floors, roofs, ceilings, walls, etc. and shall coordinate all such work with the General Contractor and all other trades. He shall coordinate with the General Contractor any openings which he is to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the responsible Contractor.

C. Each Electrical Contractor shall plan his work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for conduit, conductors, wireways, etc. to go through; however, when this is not done, this Contractor shall do all cutting and patching as well as reinforcement required for the installation of his work, or he shall pay other trades for doing this work when so directed by the Engineer. Any damage caused to the buildings by the workmen of the responsible Contractor must be corrected or rectified by him at his own expense.

D. Each Electrical Contractor shall cut holes in casework, equipment panels, etc. (if any), as required to pass pipes in and out.

E. Each Electrical Contractor shall notify other trades in due time where he will require openings of chases in new concrete or masonry. He shall set all concrete inserts and sleeves for his work. Failing to do this, he shall cut openings for his work and patch same as required at his own expense.

F. Openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe cut with a masonry saw.

G. No structural members shall be cut without the approval of the Structural Engineer and all such cutting shall be done in a manner directed by him.

H. Each Electrical Contractor shall be responsible for properly shoring, bracing, supporting, etc. any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements, shall be promptly and properly made good to the satisfaction of the Engineer.

I. All work improperly done or not done at all as required by the Electrical trades in this section will be performed by the General Contractor at the direction of the Contractor whose work is affected. The cost of this work shall be paid for by the Contractor responsible

1.34 SLEEVES AND PLATES

A. Each Contractor shall provide and locate all sleeves and inserts required for his work before the floors and walls are built, or shall be responsible for the cost of cutting and patching required where sleeves and inserts were not installed, or where incorrectly located. Each Contractor shall do all drilling required for the installation of his hangers. Drilling of anchor holes may be prohibited in post-tensioned concrete construction, in which case the Contractor shall request approved methods from the Architect and shall carefully coordinate setting of inserts, etc., with the Structural Engineer and/or Architect.

B. Galvanized steel sleeves shall be provided for all electrical conduit passing thru concrete floor slabs and concrete, masonry, tile and gypsum wall construction.

C. Cast iron sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking with lead and oakum between pipe and sleeve for waterproofing.

D. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter.

E. Where conduit motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Check floor and wall construction finishes to determine proper length of sleeves for various locations; make actual lengths to suit the following:

1. Terminate sleeves flush with walls, partitions and ceiling.
2. In areas where pipes are concealed, as in chases, terminate sleeves flush with floor.
3. In all areas where pipes are exposed, extend sleeves ½ inch above finished floor, except in rooms having floor drains, where sleeves shall be extended 3/4 inches above floor.

F. Sleeves shall be constructed of 24-gauge galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated on the drawings.

G. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction occurs around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction. Fire and smoke stop all sleeves in a manner approved by the local authority having jurisdiction or per prevailing codes.

H. Sleeves and conduits passing through exterior wall ~~(none are permitted thru roof)~~ or where there is a possibility of water leakage and damage shall be caulked water tight for horizontal sleeves and conduits. ~~and flashed and counter flashed with lead (4 lb.) or copper and soldered to the piping, lapped over sleeve and properly weather sealed.~~ All roof penetrations shall be made inside mechanical equipment curbs.

I. All rectangular or special shaped openings in plaster, stucco or similar materials including gypsum board shall be framed by means of plaster frames, casing beads, wood or metal angle members as required. The intent of this requirements is to provide smooth even termination of wall, floor and ceiling finishes as well as to provide a fastening means for lighting fixtures, panels, etc. Lintels shall be provided where indicated over all openings in bearing walls, etc.

1.35 WEATHERPROOFING

A. Where any work pierces waterproofing, including waterproof concrete, the method of installation shall be as approved by the Architect and/or Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.

B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

1.36 SMOKE AND FIRE PROOFING

A. The Contractor shall not penetrate rated fire walls, ceilings or floors with conduit, cable, bus duct, wireway or other raceway system unless all penetrations are protected in a code compliant manner which maintains the rating of the assembly. Smoke and fire stop all openings made in walls, chases, ceiling and floors. Patch all openings around conduit, wireway, bus duct, etc., with appropriate type material to smoke stop walls and provide needed fire rating at fire walls, ceilings and floors. Smoke and fire proofing materials and method of application shall be approved by the local authority having jurisdiction. Submit means to be used.

1.37 WELDING

A. The Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with the Architect's or structural Engineer's specifications for such work. If required by the Engineer, the responsible Contractor shall cut at least three welds during the job for X-raying and testing. These welds are to be selected at random and shall be tested as a part of the responsible Contractor's work. Certification of these tests and X-rays shall be submitted, in triplicate, to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests and corrective measures until satisfactory results are obtained. All welding to be accomplished by certified welder.

1.38 SCAFFOLDING, RIGGING AND HOISTING

A. Each Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required in strict accordance with OSHA Guidelines.

1.39 INSPECTION, APPROVALS AND TESTS

A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect his installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineers for unnecessary and undue work on their part.

B. Owner's and Engineer's inspections: Two inspections will be held to generate and then review punchlist items. All site visits thereafter shall be billed to the Contractor at the Engineer's standard hourly rates.

C. The Contractor shall provide as a part of this contract electrical inspection an inspector, licensed to provide such services. All costs incidental to the provision of electrical inspections shall be borne by the Contractor.

D. The Contractor shall advise each Inspection Agency in writing (with an information copy of the correspondence to the Architect and/or Engineer) when he anticipates commencing work. Failure of the Inspection Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

E. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all roughing-in without fail. Report of each such inspection visit shall be submitted to the Architect, Engineer and the Contractor within three days of the inspection.

F. Approval by an Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these plans and specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

G. Before final acceptance, the Contractor shall furnish the original and three copies of the certificates of final approval by the Electrical Inspector (as well as all other inspection certificates) to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

H. The Contractor shall test all wiring and connections for continuity and grounds before equipment and fixtures are connected, and when indicated or required, demonstrate by Megger Test the insulation resistance of any circuit or group of

circuits. Where such tests indicate the possibility of faulty insulation, locate the point of such fault, pull out the defective conductor, replacing same with new and demonstrate by further test the elimination of such defect.

1.40 OPERATING INSTRUCTIONS

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating his systems and equipment for a period of ~~three days~~one day of eight hours ~~each~~total for both schools, or as otherwise specified. During this period, instruct the Owner or his representative fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least one week's written notice to the Owner, Architect and Engineer in advance of this period. Contractor shall prepare an agenda for approval by Owner. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer with copy to the Owner and Architect that such demonstrations have taken place, noting the date, time and names of the Owner's representative that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer of typewritten and/or blueprinted instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Each section shall be properly tabbed, indexed and labeled, with a table of contents. Minimum 3-ring hard cover binder. Include specific part, catalog, model, serial, and shop order numbers; statement of warranties – indexed by section; manufacturer names, P.O.C. for warranties, etc.

C. Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

1.41 CLEANING

A. Contractor shall, at all times, keep the area of their work presentable to the public and clean of rubbish and debris caused by operations; and at the completion of the work, shall remove all rubbish, debris, all of his tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use.

B. If the Contractor does not attend to cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor.

C. Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of the Contractor's rubbish or debris.

D. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of equipment, fixtures and all other associated or adjacent fabrication.

1.42 PAINTING

A. Each fixture, device, panel, junction box, etc., that is located in a finished area shall be provided with finish of color and type as selected or approved by the Architect or Engineer. If custom color is required by the plans or specifications, it shall be provided at no additional cost to the Owner. All other equipment, fixtures or devices located in finished or unfinished areas, that are not required to have or are provided with finish color or coating shall be provided in a prime painted condition, ready to receive finish paint or coating. All galvanized metal in finished areas and exposed on exterior shall be properly prepared with special processes to receive finish paint as directed and approved by the Architect.

1.43 INDEMNIFICATION

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

1.44 HAZARDOUS MATERIALS

A. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of his work, insure that his workers are aware of this potential and what they are to do in the event of suspicion. He shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise him immediately.

D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 26 00 00

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Metal-clad cable, Type MC, rated 600 V and less.
   3. Connectors, splices, and terminations rated 600 V and less.
   4. Sleeves and sleeve seals for cables.

1.02 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.
B. NBR: Acrylonitrile-butadiene rubber.
C. VFD: Variable frequency drive.

1.03 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.
B. Product Data: For each type of product indicated. Provide data for conductors and cables including, but not be limited to, the following:
   1. Complete physical properties of the conductors and cables.
   2. Ampacity for use intended.
   3. Allowable stresses and requirements for installations, including bend radii, linear stress, and other pertinent data.
   4. Types of connectors for terminations.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For conductors and cables, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures," include the following:
   1. Manufacturer's routine maintenance requirements for cables, terminations and all installed components.

1.06 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.

1.07 COORDINATION

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

PART 2 - PRODUCTS

2.01 BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V and less.
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alcan Products Corporation; Alcan Cable Division.
   2. Alpha Wire.
   3. Belden Inc.
   4. Encore Wire Corporation.
   5. General Cable Corporation.
   6. Southwire Company.
C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL’s “Wire and Cable Marking and Application Guide.”
D. Copper Conductors: Comply with NEMA WC 70. All conductors shall be 98% conductive annealed copper unless noted otherwise. Comply with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
E. Conductor Insulation:
   1. Type THHN and Type THWN-2: Comply with UL 83.
   2. Types THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
   3. Type XHHW-2: Comply with UL 44.

2.02 MULTICONDUCTOR CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Belden Inc.
   2. Encore Wire Corporation.
   3. General Cable Corporation.
   4. Southwire Company.

B. Metal-Clad Cable, Type MC: A factory assembly of one or more current-carrying conductors with an equipment grounding conductor in an overall metallic sheath.
   1. Standards:
      a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
      b. Comply with UL 1569.
      c. Listed for use in Environmental Air space according to NPFA 70 Article 300.
      d. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
   2. Circuits:
      a. Single circuit.
      b. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.
   3. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
   4. Ground Conductor: Insulated.
   5. Conductor Insulation: Type TFN/THHN/THWN-2: Comply with UL 83.
   6. Armor: Steel, interlocked.

2.03 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Thomas & Betts (T&B).
   6. Tyco Electronics Corp.

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

C. Splicing devices for use on No. 14 to No. 10 AWG conductors shall be pressure type such as T & B "STA-KON", Burndy, Reliable or approved equivalent.

D. Wire nuts shall be spring pressure type, insulation 600V, 105 deg. C insulation, up to #8 size. Greater than #6 Cu shall be a compression type connection, 600V insulation, cold shrink tubing, taped, for full insulation value.

E. Pressure crimp-applied ring type (or fork with upturned ends) terminations shall be employed on motor and equipment terminals where such terminals are provided on motor and equipment leads or on all stranded wire terminations using #10 AWG or smaller conductors.

F. Splices, where necessary, shall be made with hydraulically-set "Hy-press" or equivalent crimped connectors. All splices shall be insulated to the full value of the wiring insulation using a cold-shrink kit or the equivalent in built-up materials.

G. Large connectors (lugs) shall be compression, hydraulically set. Lugs furnished on equipment shall be per manufacturer's recommendations.

H. Underground connections made between bare ground wires or to ground rods shall be exothermically welded, "Cadweld" or equivalent.

I. No aluminum splicing devices or connectors shall be used.

2.04 MISCELLANEOUS PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength: 50 lb, minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black, except where used for color-coding. Refer to Division 26 Section "Identification for Electrical Systems" for color-coding requirements.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper unless noted otherwise on Drawings. For feeders larger than 200A as indicated on the Electrical One-Line Diagram, aluminum may be used. Stranded for all wire.
B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.
D. Provide conductors with minimum temperature ratings of 75 degrees C. For high temperature applications, provide conductors with temperature ratings in accordance with the NFPA 70 for the ambient condition.
E. Conductors used for motor connections and connections to vibrating or oscillating equipment shall be extra flexible stranded.
F. All conductors shall be new, in good condition, and delivered in standard coils and reels.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders:
   1. Copper: Type THHN-THWN, single conductors in raceway.
B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces:
   1. Copper: Type THHN-THWN, single conductors in raceway.
C. Feeders Concealed below Slabs-on-Grade and Underground:
   1. Copper: Type THHN-THWN, single conductors in raceway.
D. Exposed Branch Circuits, Including in Crawlspaces:
   1. Copper: Type THHN-THWN, single conductors in raceway.
E. Branch Circuits Concealed in Ceilings, Walls, and Partitions:
   1. Copper: Type THHN-THWN, single conductors in raceway.
F. Branch Circuits Concealed in Concrete, below Slabs-On-Grade, and Underground:
   1. Copper: Type THHN-THWN, single conductors in raceway.
   2. Branch circuits shall not be routed in or below Slabs-On-Grade unless approved by the Engineer or serving a recessed floor box.
G. Connections to Luminaires: Metal-Clad Cable, Type MC, maximum of 72 inches.
H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
I. Class 1 Control Circuits: Type THHN-THWN, in raceway.
J. Class 2 Control Circuits: Power-limited tray cable, in cable tray.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Run feeders in continuous lengths, without joints or splices. Where continuous runs are impractical; obtain Engineer's approval for splice locations and application.
B. Branch wiring and feeder conductors that are greater than 50-feet in length shall be increased at least one size to compensate for voltage drop. All circuits shall be installed and sized for a maximum 2% voltage drop as calculated using 80% of the supply breaker rating as the load. Adjust conductors and conduit size accordingly for actual field installed conditions.
C. Make joints in branch circuits only where circuits divide.
D. Do not use gutters of panelboards as raceways, junction boxes, or pull boxes for conductors not terminating in said panelboards.
E. Run conduits for emergency power conductors separate from all other wiring.
F. Make splices and terminations in cables with kits and instructions provided by the kit manufacturer. Each splice shall equal the integrity of the cable electrically and environmentally.
~~F.~~G. For circuits that are being relocated/recircuited to a new panel in the same electrical room, match the existing conductor sizes for the extension. For circuits that are being relocated/recircuited to a new panel in a different electrical room, if the branch circuit may exceed 100-feet, those circuits shall be traced and verified that the voltage drop does not exceed 2%.
~~G.~~H. Bundling Conductors: Bundle conductors in switchboards, panelboards, cabinets, and the like, using nylon ties made for the purpose. Bundle conductors larger than No. 10 in individual circuits. Smaller conductors may be bundled in larger groups.
~~H.~~I. Install all conductors in raceways, unless otherwise indicated.
~~I.~~J. Sizes:
   1. Provide conductors no smaller than No. 12 AWG, except for signal or control circuits.
   2. Provide No. 10 AWG conductors for home runs on 120-volt, 20-ampere branch circuits, where the conductor length exceeds 100 lineal feet from panelboard to the first device.
   3. Provide No. 10 AWG conductors for home runs on 277-volt, 20-ampere branch circuits, where the conductor length exceeds 200 lineal feet from panelboard to the first device.
   4. Provide neutral conductors of the same size as the phase conductor(s) for individual branch circuit homeruns.

5. Run dedicated neutral conductor with each branch circuit. Sharing of neutral conductors in multi-circuit homeruns is not acceptable.
    a. Sharing of neutrals would necessitate the use of multiple-pole or tied branch circuit breakers to allow simultaneous disconnecting of current caring conductors in order to comply with NFPA 70 requirements and therefore is unacceptable.
6. Grouping of Multi-Circuit Homeruns: Grouping of multiple circuits into shared conduit homeruns is acceptable where they comply with the quantities and sizes listed in Table "A" below and where homeruns meet the following conditions:
    a. Where conductors are THWN/THHN installed in dry location.
    b. Where raceways are installed in ambient conditions less than 30-Deg C (86-Deg F).
    c. Consider neutral conductors as a current carrying conductor in branch circuits which serve receptacles or electronic ballasted luminaries.
    d. No more than seven conductors shall be installed in conduit except for switch legs and travelers in multi-point switching arrangements.

TABLE A

| Number of Current Carrying Conductors in single raceway | Conductor Size for 20Ampere Single Pole Circuit | Conduit Size based on EMT |
|---|---|---|
| 2 to 3 | #12 AWG (THHN 75-Deg) or #12 AWG (THHN 90-Deg) | 3/4" EMT |
| 4 to 6 | #12 AWG (THHN 75-Deg) or #12 AWG (THHN 90-Deg) | 3/4" EMT |
| 7 to 9 | #10 AWG (THHN 75-Deg) or #12 AWG (THHN 90-Deg) | 1" EMT<br>3/4" EMT |

Notes:
1. Conductor and conduit sizes in table above are based on total conductor lengths under 100 lineal feet for 120-volt (200 lineal feet for 277-volt) from panelboard to the first device, 20-ampere branch circuits. Increase conductor and conduit size in accordance with NFPA 70 for longer lengths.

K. For relocation of existing circuits to a new panel, the conduit fill and conductor derating shall be performed per the NEC requirements. Neutral conductors shall be considered a current carrying conductor.

~~J.~~L. Terminations of multiple branch circuit conductors on a single circuit breaker is not acceptable.

~~K.~~M. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

~~L.~~N. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible. Cables that are installed exposed shall not be routed across ceilings or ductwork. They shall be held up against building structure or against permanent support members. They shall be installed in such a manner that they do not interfere with the operation of equipment or removal of ceiling tiles. Nylon tie-wraps shall be installed in such a manner so as to bundle conductors neatly, allowing runouts of single conductors or groups to drop down to equipment served. Install grommeting where dropping out of trays or into panels or service columns. Install sleeves with bushings where penetrating partitions. Firestop sleeves with approved material. Do not penetrate firewalls if so indicated on plans.

~~M.~~O. Intentional or unintentional painting of exposed low voltage or line voltage cabling is prohibited. Ensure that exposed cabling is adequately protected from direct painting or overspray whether painting is required within the electrical specifications or required by other disciplines/trades. Review the painting requirements for all disciplines and provide cabling protection as required. Where exposed cabling is being installed in exposed ceilings or wall spaces that are required to be painted, provide alternate options for cable colors and submittals for such cabling for Engineer to review.

~~N.~~P. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

3.04 WIRE PULLING

A. Pull no conductors into conduits until all Work of a nature which may cause injury to conductors is completed.

B. Follow manufacturers' recommendations for regulating temperature conditions of conductors prior to installation.

C. Exercise care in handling and installing cables to avoid damage. Carefully form cables in equipment pull boxes. Form bends in cables larger than the minimum radii shown in the cable manufacturer's published data for minimum bends such that bends will not reduce the cable life.
    1. The radius of bending of conductors shall be not less than eighteen (18) times the outside diameter of the conductor insulation.

D. Provide suitable installation equipment to prevent abrasion and cutting of conductors by raceways during the pulling of conductors. Use ropes of polyethylene, nylon or other suitable non-metallic material to pull in feeders. Metallic ropes are prohibited.

E. Attach pulling lines to conductors by means of insulated woven basket grips or by pulling eyes attached directly to conductors. Do not use rope hitches, or bare steel basket grips. All conductors to be installed in a single conduit shall be pulled in simultaneously.
F. The pulling of all wires and cable on this project shall be performed in strict compliance with applicable sections of the National Electrical Code. No conductor entering or leaving a cabinet or box shall be deflected in such a manner as to cause excess pressure on the conductor insulation. Conductors shall only be installed after insulating bushings are in place.
G. Maximum permissible pulling tensions, as recommended by the manufacturer for any given type of cable or wire installed shall not be exceeded. Utilize special remote readout equipment to ensure compliance.
H. Before any wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire itself to be pulled into a clean, dry conduit.
I. Use manufacturer-approved pulling compound or lubricant where necessary, of non-conducting type. Compounds used must not deteriorate the conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 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 12 inches of slack.
D. Wiring at Lighting Control Locations: Install a neutral conductor at each switch location controlling line-to-neutral lighting loads.
E. Connectors: Make splices and connections in conductors using approved connectors.
    1. Provide lugs and connectors of proper size to match conductor size.
    2. Stranded Conductors: Solder-less, bolted pressure or compression connectors.
    3. Solid Conductors: Bolted pressure or spring connectors.
    4. Motor Lead Pigtails: Crimp lugs with through-bolt fasteners between lugs. Furnish proper sized dies and tools to apply connectors.
    5. Lighting Fixture Taps: Electrical spring connectors as specified for solid conductors.
    6. Ground Connections: Ground connection materials and installation requirements are specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
    7. Wire Nuts:
        a. For up to #8 AWG in size, use spring pressure type, insulation 600V, 105 deg C insulation
        b. For greater than #8 AWG in size, use compression type connection, 600V insulation, cold shrink tubing, taped, for full insulation value.
F. Provide temperature ratings of connectors and splices to match wire rating.

3.07 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.08 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Firestopping."

3.09 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
    1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for one minute.
    2. Perform continuity test to insure correct cable connection.
    3. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors of No. 2 AWG and larger for compliance with requirements.
    4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    5. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
b. Perform follow-up infrared scans at 11 months after Substantial Completion.
c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. 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.

C. Cables will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

A. NFPA 70 and IEEE C2 include basic grounding requirements for electrical safety. This Section supplements the minimum safety requirements of the Code with requirements for additional grounding and with optional grounding methods and materials for both power and electronic systems.

B. This section also includes grounding and bonding for Division 27 communications systems.

1.02 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. TGB: Telecommunications grounding busbar.

C. TMGB: Telecommunications main grounding busbar.

D. BMGB: Building main grounding busbar.

E. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

1.03 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

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

C. Shop Drawings for Grounding Electrode System: Include dimensioned plans of proposed grounding electrodes and how the electrodes are bonded together to form the grounding electrode system. This should include all grounding electrode conductors specified herein. Include grounding electrode conductors for both under/within the building pad as well as on the Project site.

D. Shop Drawings: For communications equipment room, include plans, elevations, sections, details, and attachments to other work.

E. Maintenance Data: For connectors to include in maintenance manuals.

1.04 INFORMATIONAL SUBMITTALS

A. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Grounding arrangements and connections for separately derived systems.
4. Grounding for sensitive electronic equipment.

B. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, include the following:

1. BCT, TMGB, TGBs, and routing of their bonding conductors.

C. Source quality-control reports.

D. Field quality-control test reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures," include the following:

1. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems and 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.
   c. Result of the ground-resistance test, measured at the point of BCT connection.
   d. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.06 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 NFPA 70.

D. Comply with IEEE C2.

E. Comply with ANSI-J-STD-607-A.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Burndy; Part of Hubbell Electrical Systems.
   2. Dossert; AFL Telecommunications LLC.
   3. ERICO International Corporation.
   4. Fushi Copperweld Inc.
   5. Galvan Industries, Inc.; Electrical Products Division, LLC.
   6. Harger Lightning and Grounding.
   7. ILSCO.
   8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
   9. Robbins Lightning, Inc.
   10. Siemens Power Transmission & Distribution, Inc.

2.02 CONDUCTORS

A. Insulated Conductors: Copper wire, green or green with yellow stripe insulation, insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, and complying with UL 83.
   1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
   2. Cable Tray Equipment Grounding Wire: No 6 AWG.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.
   2. Stranded Conductors: ASTM B 8.
   3. Tinned Conductors: ASTM B33.
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Cable Tray Grounding Jumper:
   1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hold ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

2.03 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. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
   1. Electroplated tinned copper, C and H shaped.

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

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

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

G. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

H. Cable Tray Ground Clamp: Cast silicon bronze, solderless compression, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar..

I. Conduit Hubs: Mechanical type, terminal with threaded hub.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

L. Water Pipe Clamps:
   1. Mechanical type, two pieces with zinc-plated bolts.
      a. Material: Die-cast zinc alloy.
      b. Listed for direct burial.
   2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.04 ELECTRICAL GROUND BARS

A. Grounding Bus: Predrilled rectangular bars of annealed copper, ¼ by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V. Lexan or PVC, impulse tested at 5000 V.

2.05 ELECTRICAL GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 5/8-inch diameter by 96 inches long.

B. Other grounding electrodes permitted for grounding per NFPA 70 include:

1. Metal Underground Water Pipe: A metal underground water pipe in direct contact with the earth for a minimum of 10-feet and electrically continuous.
2. Building Steel: The hold-down bolts securing the structural steel column shall be connected to the concrete-encased electrode.

PART 3 - EXECUTION

3.01 APPLICATIONS

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

B. Grounding Conductors: Green-colored insulation with continuous yellow stripe.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches minimum from wall,12 inches above finished floor unless otherwise indicated.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Ground Rods: Welded connectors.
5. Connections to Structural Steel: Welded connectors.
6. Connections to Concrete-Encased Electrode: Welded connectors.

E. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

F. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in 3/4-inch EMT conduit until conduit enters an electrical or telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
    a. For communications grounding, if a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Division 26 Section "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.02 GROUNDING BUSBARS

A. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.

3.03 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the main electrical room ground bus which shall be connected to the main switchboard ground bus. Install a main bonding jumper between the neutral and ground bus in the main service entrance switchboard.

3.04 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

B. Dry-Type Transformers: Install an insulated grounding conductor from the common point of connection of the transformer secondary neutral point and the transformer enclosure to the following:

1. The grounding bus of the common electrode grounding system, located in the electrical equipment room.

3.05 EQUIPMENT GROUNDING

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

1. Bond to each device, box, and luminaire, unless otherwise indicated.

2. Conductor insulation of the same rating as the phase conductors, for all feeders and branch circuits. Install the grounding conductors in the raceway with related phase and neutral conductors.
3. Where parallel conductors in separate raceways occur, provide a grounding conductor in each raceway that meets requirements of NFPA 70.

B. Enclosures: Install an insulated grounding conductor from grounding bushings to the frame of the enclosure, ground bus, and equipment grounding strap where each occurs. Install grounding bushings on all raceways connecting electrical enclosures constructed of separate enclosure panels, which are not integrally welded together.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. 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.
1. 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.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.06 COMMUNICATIONS GROUNDING CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
1. Use crimping tool and the die specific to the connector.
2. Pre-twist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground.

F. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

G. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

H. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-C.1 and TIA/EIA-568-C.2 when grounding screened, balanced, twisted-pair cables.

I. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.07 INSTALLATION

A. All new circuits shall have a separate grounding conductor. For branch circuits that are being relocated to a new panel, match the existing grounding conductor installation. If each branch circuit does not have its own separate grounding conductor, each raceway shall have an equipment ground at a minimum.

B. Provide permanent service neutral and equipment grounding in accordance with NFPA 70 and subject to the following additional requirements.

C. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Connect the service neutral and equipment ground to a common point within the metallic enclosure containing the main service disconnecting means. Equipment grounds and the identified neutral of the wiring system shall not be interconnected beyond this point in the interior wiring system. From the common point of connection of the service neutral and the equipment ground, run in non-magnetic conduit a grounding electrode conductor without joint or splice to the grounding electrode system and connect it with an approved bolted pressure clamp.

E. 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.

F. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. 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.

G. 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 deep, with cover.
   1. 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.

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

I. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install bare copper grounding conductors from building's main electrical room 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.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

J. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

L. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

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

C. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

D. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8-inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

E. Labels shall be preprinted or computer-printed type.
   1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.

2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.09 FIELD QUALITY CONTROL

A. Perform tests and inspections.

~~1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.~~

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. 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.
   b. Perform tests by fall-of-potential method according to IEEE 81.
4. Prepare dimensioned Drawings locating each 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.
5. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
   a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
6. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
   a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB. Maximum acceptable ac current level is 1 A.

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

1. Power and Lighting Equipment or System with Capacity of 1000 kVA and Less: 5 ohms.
2. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm.
4. Substations and Pad-Mounted Equipment: 5 ohms.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance. If resistance to ground at the BCT exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.

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

F. Prepare test and inspection reports.

END OF SECTION 26 05 26

SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Conduit, ducts, and duct accessories for exterior, underground, direct-buried duct banks.
   2. Handholes and boxes.

B. Related Sections include the following:
   1. Division 26 Section "Raceways and Boxes for Electrical Systems" for raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.02 DEFINITION

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
B. Duct: An underground raceway. This term may be used interchangeably with the term raceway.
C. Duct Bank: Two or more raceways grouped together, irrespective of duct material or encasement material.
D. ENT: Electrical Non-Metallic Tubing
E. EPC: Electrical Polyvinyl Chloride (PVC) Conduit
F. RMC: Rigid metal conduit.
G. RNC: Rigid nonmetallic conduit.
H. RSC: Rigid Steel conduit.
I. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.03 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

B. Product Data: For the following:
   1. Duct-bank materials, including separators and miscellaneous components.
   2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Underground-line warning tape.

C. Shop Drawings for Underground Conduit Routing: Include dimensioned plans of proposed underground conduit routing with each conduit labeled with its associated service. Include underground conduit routing for both under the building pad as well as on the Project site.
   1. Include plans and sections, drawn to scale, as show bends and locations of expansion fittings (if necessary).
   2. Show duct profiles and coordination with other utilities and underground structures.

D. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Reinforcement details.
   3. Frame and cover design and manhole frame support rings.
   4. Ladder details.
   5. Grounding details.
   6. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons, and sumps.
   7. Joint details.

1.04 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

C. Source quality-control test reports.
D. Field quality-control test reports.

1.05 QUALITY ASSURANCE

A. Comply with ANSI C2.
B. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

1.07 COORDINATION

A. Coordinate layout and installation of ducts, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

PART 2 - PRODUCTS

2.01 METAL CONDUITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. Allied Tube & Conduit; a Tyco International Ltd. Co.
   3. Anamet Electrical, Inc.
   4. Calbond
   5. Electri-Flex Company.
   6. O-Z/Gedney; a brand of EGS Electrical Group.
   7. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
   8. Plasti-Bond
   9. Republic Conduit.
   10. Robroy Industries.
   11. Southwire Company.
   12. Thomas & Betts Corporation.
   13. Western Tube and Conduit Corporation.
   14. Wheatland Tube Company; a division of John Maneely Company.

B. RSC: Rigid Steel Conduit, Galvanized. Comply with 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, minimum.

2.02 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ARNCO Corp.
   2. Beck Manufacturing.
   3. Cantex, Inc.
   4. CertainTeed Corp.; Pipe & Plastics Group.
   5. Condux International, Inc.
   6. ElecSys, Inc.
   7. Electri-Flex Company.
   8. IPEX Inc.
   9. Lamson & Sessions; Carlon Electrical Products.
   10. Manhattan/CDT; a division of Cable Design Technologies.
   11. Spiraduct/AFC Cable Systems, Inc.

B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

C. Underground Plastic Utilities Duct: Type EPC-40-PVC and Type EPC-80-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 and UL 514B by same manufacturer as duct.

D. Duct Accessories:
   1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
   2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

2.03 PRECAST CONCRETE HANDHOLES AND BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carder Concrete Products.
   2. Christy Concrete Products.
   3. Elmhurst-Chicago Stone Co.
   4. Oldcastle Precast Group.
   5. Riverton Concrete Products; a division of Cretex Companies, Inc.

6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
1. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
a. Cover Hinges: Concealed, with hold-open ratchet assembly.
b. Cover Handle: Recessed.
2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, As indicated for each service.
4. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
a. Extension shall provide increased depth of 12 inches.
b. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
6. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
a. Type and size shall match fittings to duct or conduit to be terminated.
b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
7. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.04 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.
1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have integral closed 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, "ELECTRIC," "TELEPHONE," or as indicated for each service.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a 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:
a. Armorcast Products Company.
b. Carson Industries LLC.
c. CDR Systems Corporation.
d. NewBasis.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Carson Industries LLC.
b. Christy Concrete Products.
c. Nordic Fiberglass, Inc.

2.05 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the 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

3.01 PREPARATION

A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into handholes and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to handholes, and as approved by Architect.

C. Remove and stockpile topsoil for reapplication according to Division 31 Section "Site Clearing."

3.02 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in directy-buried duct bank, unless otherwise indicated.

B. Ducts for Electrical Feeders and Branch Circuits on Project Site: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated. Branch circuits inside the building shall not be routed underground unless noted otherwise.

C. Underground Ducts Crossing ~~Paved Paths, Walks,~~ Driveways~~,~~ and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

~~C.~~D. Underground Ducts Crossing Paved Paths and Walks: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

3.03 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

3.04 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

1. Beyond building perimeter, provide bentonite “trench plug” that extends at least 5 feet out from the face of the building’s exterior.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

3.05 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Depths of bury shall be:

1. 42” minimum to top of primary ducts
2. 36” minimum to top of secondary ducts
3. 36” minimum to top of branch exterior circuits
4. 36” minimum to top of telephone/communications ducts

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares.
H. Concrete-Encased Ducts: Support ducts on duct separators.
   1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Division 31 Section “Earth Moving” for pipes less than 6 inches in nominal diameter.
   2. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concrete pouring. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   3. Concrete: All concrete used in duct bank construction shall be 3000 PSI minimum 28-day compressive strength unless otherwise noted in accord with latest ACI standards complying with Division 03 Section "Cast-in-Place Concrete." Testing of concrete shall be the responsibility of the Contractor.
   4. Concrete Pouring Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
      a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
      b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
   5. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
   6. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall.
   7. Concrete Reinforcement: Reinforce concrete-encased duct banks at each corner of duct bank with a minimum No. 4 steel reinforcing bar with 3-inch concrete cover on all sides. Lap bars fifteen diameters at all splices. Reinforcing steel shall be rigidly supported during pour and vibration. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
   8. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
   9. Install backfill as specified in Division 31 Section "Earth Moving."
      a. Backfill shall be accomplished with clean debris free earth and tamped at 12-inch intervals so as to avoid earth sinks along the trench.
      b. Backfill trenches only after conduit has been inspected by Agencies, Engineer and Owner, tested, and locations of lines have been recorded on Record Drawings. Provide at least one week’s written notification to all parties of impending work that needs to be reviewed.
      c. Backfill below paved areas shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill.
      d. Backfill below sodded or seeded areas shall be brought to within six inches of finished grade. The remaining six inches shall be backfilled with clean soil.
      e. Concrete for concrete encasement shall cure a minimum of 3 days prior to backfill.
   10. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
   11. Stub-Ups: Use manufactured PVC-coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
      a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
      b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend PVC-coated steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
   12. Detectable Warning Tape: Bury detectable warning tape approximately 18 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.
I. Direct-Buried Duct Banks:
   1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
   2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct

movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.

3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving."
   a. Backfill around conduits with red sand to provide a minimum of 4-inches of cover on top of conduits.
   b. Remaining backfill shall be accomplished with clean debris free earth and tamped at 12-inch intervals so as to avoid earth sinks along the trench.
   c. Backfill trenches only after conduit has been inspected by Agencies, Engineer and Owner, tested, and locations of lines have been recorded on Record Drawings. Provide at least one week's written notification to all parties of impending work that needs to be reviewed.
   d. Backfill below paved areas shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill.
   e. Backfill below sodded or seeded areas shall be brought to within six inches of finished grade. The remaining six inches shall be backfilled with clean soil.
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Width: Excavate trench 3 inches wider than duct on each side.
8. Set elevation of bottom of duct bank below the frost line.
9. Stub-Ups: Install manufactured PVC-coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. For equipment mounted on outdoor concrete bases, extend PVC-coated rigid steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
10. Detectable Warning Tape: Bury detectable warning tape approximately 18 inches above all direct bury duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.06 INSTALLATION OF CONCRETE HANDHOLES AND BOXES

A. Precast Concrete Handhole Installation:
   1. Comply with ASTM C 891, unless otherwise indicated.
   2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
   3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
B. Elevations:
   1. Install handholes with bottom below the frost line.
   2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
   3. Where indicated, cast handhole cover frame integrally with handhole structure.
C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
D. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.
E. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.07 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.
D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
E. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
1. Concrete: 3000 psi, 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.08 GROUNDING
A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.09 FIELD QUALITY CONTROL
A. Perform the following tests and inspections and prepare test reports:
1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING
A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 05 43

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Identification for conductors.
   2. Underground-line warning tape.
   3. Warning labels and signs.
   4. Equipment identification labels.
   5. Miscellaneous identification products.

B. Related Sections include the following:
   1. Division 26 Section "Wiring Devices" for engraved wall plates and wiring device identification requirements.

1.02 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

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

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

D. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.03 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

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.

1.04 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. Coordinate installation of identifying devices with 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.

PART 2 - PRODUCTS

2.01 CONDUCTOR IDENTIFICATION MATERIALS

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

B. Self-Adhesive Wraparound Labels: Write-on, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Gardner.
      c. T&B.
   2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
   3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.02 UNDERGROUND-LINE WARNING TAPE

A. Tape:
   1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
   2. Printing on tape shall be permanent and shall not be damaged by burial operations.
   3. 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.
   4. Tape to be minimum 6 mil thick and 6-inches wide with aluminum backing to be detectable underground using a non-ferrous locator.

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, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.03 WARNING LABELS AND SIGNS
A. Comply with NFPA 70 and 29 CFR 1910.145.
B. 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.
C. Warning label 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. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR ## INCHES." Verify work space required for specific project conditions with NFPA 70 and replace "##" in previous sentence with appropriate distance.
3. Arc Flash Warning and Instruction: "WARNING – ARC FLASH AND SHOCK HAZARD. WEAR APPROPRIATE PPE." Determine appropriate protective clothing and personal protective equipment (PPE) for the task from NFPA 70E.

2.04 EQUIPMENT IDENTIFICATION LABELS
A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
a. Power Circuits:
1) Normal: White lettering on Black background.
2) Emergency and Legally Required Standby: White lettering on Red background.
3) Optional Standby: Red lettering on Yellow background.

2.05 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.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black except where used for color-coding.
B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.
C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.06 MISCELLANEOUS IDENTIFICATION PRODUCTS
A. 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

3.01 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. Conductor Color-Coding Key: Install Instructional Label denoting the conductor color-coding scheme on all panelboards, distribution boards, switchboards, switchgear, motor-control center and similar equipment.

F. All conductors shall be identified by color code and by means of labels placed on conductors in junction boxes and at terminal points with labels indicating source, circuit No. or terminal No.

G. Conductor Color-Coding for Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   1. Color shall be factory applied to conductors or for sizes larger than No. 8 AWG, if authorities having jurisdiction permit, field applied.
   2. Colors for Grounding Conductors:
      a. Equipment Grounding Conductor: Green.
   3. Colors for 208/120-V Wye Systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Grounded Conductor (Neutral): White
   4. Colors for 480/277-V Wye Systems:
      a. Phase A: Brown.
      b. Phase B: Purple.
      c. Phase C: Yellow.
      d. Grounded Conductor (Neutral): Gray
   5. Control Wiring: Red, or as indicated.
   6. D.C. Wiring:
      a. Positive: Light Blue
      b. Negative: Dark Blue
   7. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inchesfrom 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.

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 detectable underground-line warning tape approximately 18 inches above all concrete-encased ducts and direct bury duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.02 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches 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 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. System legends shall be as follows:
   1. Emergency Power.
   2. Power.

C. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

D. 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.

E. Locations of Underground Lines: Identify with detectable 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.

F. 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.

G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
   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.
   5. For equipment requiring workspace clearance according to NFPA 70, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
   6. Arc Flash Warning Labels: Apply label to door or cover at all access point of equipment including, but not limited to, the following:
      a. Disconnect switches.
      b. Electrical switchboards.
      c. Emergency system boxes and enclosures.
      d. Enclosed circuit breakers.
      e. Meter Sockets and assemblies.
      f. Motor starters.
      g. Motor-control centers.
      h. Panelboards.
      i. Power transfer equipment (ATS).
      j. Transformers.
   7. Available Fault Current Field Marking: Apply label to cover of existing and new service equipment enclosure with the date in which the fault current was calculated and the available fault currentas determined by the OCPD coordination study. Table 1 below lists a typical example of label format, coordinate project specific requirements with Drawings.

Table 1 (Example Only)

| MAX. AVAILABLE FAULT: XX,XXXA<br>DATE: X/X/XX |
|---|

H. Junction Boxes and Pull Boxes: Identify voltage, source, and circuit number(s) on cover of pull and junction boxes with hand-written legible block lettering using black permanent marking pen.

I. Wiring Devices: Identify each receptacle with panelboard identification and circuit number. For devices located within 6-foot of sink, use engraved machine printing with black-filled lettering on face of plate and durable wire markers or tags inside outlet boxes. For all other devices, use clear self-adhesive label with black lettering on face of plate and durable wire markers or tags inside outlet boxes.

J. Labeling at HVAC Terminal Boxes Above Ceiling: Provide a permanent engraved label on each terminal box indicating the panel and circuit designation.

~~K. Panelboard Naming Convention Sign: Inside each electrical room, provide an engraved, melamine sign with the panelboard naming convention legend mounted on a wall.~~

~~L.~~K. Electrical Room Door Sign: Provide an engraved, melamine sign on door of electrical room that states “Per Fire Marshal, no storage is allowed in this room.” This applies to any electrical room that is affected by the scope of work of this project.

~~M.~~L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, 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-high letters on 1-1/2-inch-high label; where two lines of text or more are required, use label height as required to accommodate 3/8-inch-high letters.
      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.
   2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
e. Emergency system boxes and enclosures.
f. Enclosed switches.
g. Enclosed circuit breakers.
h. Enclosed controllers.
i. Push-button stations.
j. Power transfer equipment.
k. Contactors.
l. Remote-controlled switches, dimmer modules, and control devices.
m. Power-generating units.
n. Monitoring and control equipment.

3. Provide identification for each feeder overcurrent protective device in each switchgear, switchboard, distribution panelboard, motor control center, and any other similar equipment furnished under this Division, identification as to the specific load that it serves.
4. Provide brass phase rotation tags for each 3-phase motor securely attached to the equipment.

END OF SECTION 26 05 53

SECTION 26 05 73 - OVERCURRENT PROTECTIVE DEVICE STUDIES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on Engineer's review of submitted results of the protective device coordination study.

1. Coordination of series-rated devices is not permitted.
2. Delegated Design Requirements for Arc Flash Hazard Analysis.

~~2.~~B. This study is required from the main service through any downstream switchboards and panelboards to new equipment being installed including the generator and automatic transfer switch. Also, any existing panels that are being refed as part of this project shall be included in these studies. Any equipment that is not being touched or affected by this project scope of work does not need to be included in these studies.

1.02 PERFORMANCE REQUIREMENTS

A. Overcurrent Protective Device Coordination: All other overcurrent protective devices proposed for inclusion in the Work shall be selected to be coordinated with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency power to 0.10 seconds.

B. Delegated Design for Arc Flash Hazard Analysis: Prepare computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Electrical Shop Drawings and Submittals" for products specified under PART 2 - PRODUCTS.

B. Product Data: For computer software program to be used for studies.

C. Simultaneous Action Submittals: The following action submittals shall be made in conjunction with the approval process for system protective devices specified in other Division 26 Sections. The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section "Submittal Procedures" to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor's failure to coordinate simultaneous action submittals will not be considered by the Owner. The following submittals shall be in digital form:

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.
3. Coordination-Study Report.
4. Arc flash study input data, including completed computer program input data sheets.
5. Arc Flash Hazard Analysis Report.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For coordination-study specialist.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399. For arc flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures," include the following:

1. The following parts from the Protective Device Coordination Study Report:
   a. One-line diagram.
   b. Protective device coordination study.
   c. Time-current coordination curves.
   d. Coordination setting schedules.
2. Power system data.

B. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

C. Operation and Maintenance Procedures: In addition to items specified in Division 01 Section "Closeout Procedures," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.06 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
D. Comply with IEEE 399 for general study procedures.
E. Comply with IEEE 1584 for performing Arc Flash Hazard Calculations.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS
   A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
      1. SKM Systems Analysis, Inc.

2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS
   A. Comply with IEEE 242 and IEEE 399 for fault-current and overcurrent protective device coordination studies.
   B. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.03 SHORT-CIRCUIT STUDY REPORT CONTENTS
   A. Executive Summary
   B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
   C. One-line diagram, showing the following:
      1. Protective device designations and ampere ratings.
      2. Cable size and lengths.
      3. Transformer kilovolt ampere (kVA) and voltage ratings.
      4. Motor and generator designations and kVA ratings.
      5. Switchboard and panelboard designations.
   D. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
   E. Short-Circuit Study Output:
      1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
         a. Voltage.
         b. Calculated symmetrical fault-current magnitude and angle.
         c. Fault-point X/R ratio.
         d. No AC Decrement (NACD) ratio.
         e. Equivalent impedance.
         f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
         g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

2.04 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS
   A. Executive summary.
   B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
   C. One-line diagram, showing the following:
      1. Protective device designations and ampere ratings.
      2. Cable size and lengths.
      3. Transformer kilovolt ampere (kVA) and voltage ratings.
      4. Motor and generator designations and kVA ratings.
      5. Switchboard and panelboard designations.
   D. Study Input Data: As described in "Power System Data" Article.
   E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article above.
   F. Protective Device Coordination Study:
      1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
         a. Phase and Ground Relays:
            1) Device tag.
            2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
            3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:
1) Adjustable pickups and time delays (long time, short time, ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.
c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
a. Power utility's overcurrent protective device.
b. Medium-voltage equipment overcurrent relays.
c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
f. Cables and conductors damage curves.
g. Ground-fault protective devices.
h. Motor-starting characteristics and motor damage points.
i. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

2.05 ARC FLASH STUDY REPORT CONTENT

A. Executive summary.
B. Study descriptions, purpose, basis and scope.
C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.
D. Study Input Data: As described in “Power System Data” Article.
E. Protective Device Coordination Study Report Contents: As specified in “Protective Device Coordination Study Report Contents” Article above.
F. Arc-Flash Study Output:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
G. Incident Energy and Flash Protection Boundary Calculations:
1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.

8. Recommendations for arc-flash energy reduction.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

I. Equipment specific Arc Flash Warning Labels.

2.06 ARC-FLASH WARNING LABELS

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Flash Hazard Boundary
2. Short Circuit Current Available
3. Shock Hazard when Cover is Removed
4. Limited Approach Boundary
5. Restricted Approach Boundary
6. Prohibited Approach Boundary
7. PPE Requirements, including the following:
   a. Hazard Risk Category
   b. Required Minimum Arc Rating of PPE in cal/cm^2
   c. Clothing Description
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled.
   a. Coordination study shall accompany submission of relevant equipment submittals.

3.02 POWER SYSTEM DATA

A. Delegated Design System Analyst performing the short-circuit, protective device coordination study and arc flash hazard analysis shall furnish the Contractor with a list of required data immediately after award of the contract. Contractor shall expedite collection of the data to ensure completion of the study and analysis as required.

B. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

C. Source combination shall include present and future motors and generators indicated in the documents.

D. If applicable, include fault contribution of existing motors in the study and analysis.

E. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
   a. Circuit-breaker and fuse-current ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   d. Generator short-circuit current contribution data, including short-circuit reactance, rated kilovolt amperes, size, rated voltage, and X/R ratio.
   e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   f. Busway ampacity, impedance, lengths, and conductor material.
   g. Motor horsepower and code letter designation according to NEMA MG 1.
   h. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
   i. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Time-current-characteristic curves of devices indicated to be coordinated.
g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.03 FAULT-CURRENT STUDY

A. A short-circuit current ratings indicated in the Contract Documents are based on Fault-Current study prepared by the Engineer during design and are based on available information and anticipated feeder lengths. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
1. Electric Utility's supply termination point.
2. Service Entrance Equipment: Existing.
3. Switchboard bus.
4. Distribution panelboard.
5. Branch circuit panelboard.
6. Enclosed Fused Switch.
7. Enclosed Circuit Breaker.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculate short-circuit currents according to IEEE 551.

E. In addition to IEEE 551 short-circuit current calculations, calculate the short-circuit currents at the following:
1. Motor Controllers: Rated greater than or equal to 2hp at 300V or more.
2. Air-Conditioning and Refrigerating Equipment Controllers: Including, but not limited to, equipment supplied from a branch circuit protected at greater than 60A.
3. Elevator Controllers.

F. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
1. Transformers:
a. ANSI C57.12.10.
b. ANSI C57.12.22.
c. ANSI C57.12.40.
d. IEEE C57.12.00.
e. IEEE C57.96.
2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
3. Low-Voltage Fuses: IEEE C37.46.

G. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram, including existing and new Service Entrance equipment.

H. Equipment Evaluation Report:
1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Ensure that short-circuit withstand ratings are equal to or higher than the calculated ½-cycle symmetrical fault current for the following:
a. Electrical Distribution Equipment: Including, but not limited to, switchgear, switchboards, and panel boards.
b. Motor Controllers.
c. Air-Conditioning and Refrigerating Equipment Controllers.

4. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
5. Notify Engineer, in writing, of any existing circuit protective devices improperly rated for the calculated available fault current.

3.04 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
   1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
   2. Calculate the maximum and minimum ground-fault currents.
B. Comply with IEEE 242 recommendations for fault currents and time intervals.
C. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
   1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
      a. Device tag.
      b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
      c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
      d. Fuse-current rating and type.
      e. Ground-fault relay-pickup and time-delay settings.
   2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
      a. Device tag.
      b. Voltage and current ratio for curves.
      c. Three-phase and single-phase damage points for each transformer.
      d. No damage, melting, and clearing curves for fuses.
      e. Cable damage curves.
      f. Transformer inrush points.
      g. Maximum fault-current cutoff point.
      h. Motor starting characteristics, damage points and overload relay.
      i. Thermal damage curve for motors larger than 100 HP.
F. Completed data sheets for setting of overcurrent protective devices.
G. Complete Schedule of breaker settings to summarize information contained on data sheets. Sample schedule has been included at the end of this section for preferred format.

3.05 ARC FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.
B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system where work could be performed on energized parts including, but not limited to, the following:
   1. Disconnect switches.
   2. Electrical switchgear and switchboards.
   3. Enclosed circuit breakers.
   4. Motor starter.
   5. Panelboards.
   6. Transformers.

C. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent protection relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

D. Calculate the arc-flash protection boundary and the corresponding incident energy calculations for multiple system scenarios to be compared and the greatest incident energy to be uniquely reported for each equipment location. Calculations to be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions.
   1. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off).
   2. The maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. .

E. Incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors to be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
   2. Fault contribution from synchronous motors should be decayed to match the actual decrement of each as closely as possible.

F. For each equipment location with a separately enclosed main device, calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.
   1. When performing incident energy calculations on the line side of a main breaker, the line side and load side contributions must be included in the fault calculation.

G. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device to compute the incident energy for the corresponding location.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash even, a maximum clearing time based on the specific location shall be utilized.

I. Complete Arc Flash report to be used for the preparation of Arc Flash Warning labels for electrical equipment. Refer to Division 26 Section “Identification for Electrical Systems” for requirements of Arc Flash Study and labels.

3.06 CORRECT DEFICIENCIES, RE-CALULCATE AND REPORT

A. After Engineer’s initial review, correct unsatisfactory conditions and recalculate to demonstrate compliance; resubmit overcurrent protective devices as required to bring system into compliance.

B. Revise and Resubmit report multiple times as necessary to demonstrate compliance with requirements.

3.07 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels as specified in Division 26 Section “Identification for Electrical Systems”. Install labels under the direct supervision and control of the Arc-Flash Hazard Study Specialist.

END OF SECTION 26 05 73

SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following types of dry-type transformers with a nominal primary and secondary rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.

1.02 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

B. Specification Compliance Certification: Submit a Specification Compliance Certification in accordance with Division 26 Section “Electrical Shop Drawings and Submittals”.

C. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
   1. Include typical manufacturer’s test data reports for each type and size transformer. Reports shall include but not be limited to the following data:
      a. Efficiency in accordance with DOE 2016 Efficiency 10 CFR Part 431.
      b. Efficiency at 50- and 100-percent load under linear load.
      c. Losses in Watts at no load and full load conditions per NEMA ST20.
      d. Percent X and Percent R values,
      e. Maximum sound level of transformer in enclosure (in dBA).
      f. Maximum 30-Deg hot spot and average temperature rise over a 40-degree C ambient.

D. Shop Drawings:
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: Power, signal, and control wiring.

E. Warranty: Copy of special warranty specified in this Section.

1.03 INFORMATIONAL SUBMITTALS

A. Source quality-control test reports.

B. Field quality-control test reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals. Include the following:
   1. Manufacturer’s routine maintenance requirements for transformers and all installed components.

B. Warranty: Copy of special warranty.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer, unless otherwise indicated.

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.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Prepare equipment for shipment.
   1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
   2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

B. Installation Pathway: Coordinate delivery of equipment to allow movement into designated space.
   1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
   2. Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.

C. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
   1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer’s packaging.

D. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

E. Store equipment indoors in clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.
F. Handle equipment components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.07 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of transformers that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Standard Transformers: Two (2) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by Square D, Schneider Electric. The following manufacturer's may be submitted as an alternate:
1. ABB (General Electric Company); Industrial Connections & Solutions, LLC.
2. Acme Electric; Hubbell.
3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Mirus International, Inc.
5. Powersmiths International Corp.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."
D. Cores: Electrical grade, non-aging, silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below saturation to allow for a minimum of 10% over voltage excitation. The core laminations shall be tightly clamped and compressed.
1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.
E. Coils: Continuous windings without splices except for taps.
1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.
4. Vacuum impregnated with non-hygroscopic, thermosetting varnish.
F. Taps for Transformers Smaller Than 3 kVA: None.
G. Taps for Transformers 7.5 to 14 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
H. Taps for Transformers 15 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

2.03 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
B. Transformers Rated 15 kVA and Larger:
1. Comply with 10 CFR Part 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
C. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
D. Enclosure for Interior Transformers: Ventilated, NEMA 250, Type 2.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
2. Core of the transformer shall be grounded to the enclosure with a flexible copper strap that is fully-rated as a grounding conductor.
3. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
4. Wiring Compartment: Sized for conduit entry and wiring installation.
E. Transformer Enclosure Finish: Comply with NEMA 250. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of a polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces.
1. Finish Color: Gray weather-resistant enamel.

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
   1. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
   2. The maximum top of case temperature shall not exceed 35 deg C above ambient.
G. Grounding: Provide ground bar kit or a ground bar installed on the inside of the transformer enclosure.
H. Impedance: Between 3.5% and 5.8% unless otherwise noted.
I. Wall Brackets: Manufacturer's standard brackets.
J. Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:
   1. 9 kVA and Less: 40 dBA.
   2. 10 to 30 kVA: 45 dBA.
   3. 31 to 50 kVA: 45 dBA.
   4. 51 to 150 kVA: 50 dBA.
   5. 151 to 300 kVA: 55 dBA.
   6. 301 to 500 kVA: 60 dBA.
   7. 501 to 700 kVA: 62 dBA.
   8. 701 to 1000 kVA: 64 dBA.

2.04 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.05 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
   1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
   2. Ratio tests at rated voltage connections and at all tap connections.
   3. Phase relation and polarity tests at rated voltage connections.
   4. No load losses, and excitation current and rated voltage at rated voltage connections.
   5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
   6. Applied and induced tensile tests.
   7. Regulation and efficiency at rated load and voltage.
   8. Insulation-Resistance Tests:
      a. High-voltage to ground.
      b. Low-voltage to ground.
      c. High-voltage to low-voltage.
   9. Temperature tests.
B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATION

A. Transformer Mounting
   1. 15 kVA or less: Floor mounted or suspended, as indicated.
   2. 30 kVA and 45kVA: floor mounted, rack mounted or suspended, as indicated.
   3. 75 kVA: Floor mounted or rack mounted, as indicated.
   4. Greater than 75 kVA: Floor mounted or rack mounted, unless otherwise indicated.

3.03 INSTALLATION

A. Comply with NECA 409, “Recommended Practice for Installing and Maintaining Dry-Type Transformers” as published by the National Electrical Contractors Association.
B. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
C. Install transformer level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

D. Construct concrete bases and anchor floor-mounting transformers level on concrete bases, 4-inch nominal thickness according to manufacturer's written instructions and requirements in Division 26 Section "Hangers and Supports for Electrical Systems." Concrete materials and installation requirements are specified in Division 3.
E. Construction steel channel support system for rack-mounted or suspended transformers according to manufacturer's written instruction and requirements of Division 26 Section "Hangers and Supports for Electrical Systems."
F. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
G. Remove shipping bolts, blocking, and wedges.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
B. Transformer Nameplates: Label each transformer with Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

3.05 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
D. Provide flexible metal conduit with a minimum 12-inch to a maximum 24-inch length for wiring connections to transformer enclosure.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
~~1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.~~
B. Tests and Inspections:
1. Visual and Mechanical Inspection:
a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean and free from foreign materials.
e. Perform specific inspections and mechanical tests recommended by manufacturer including ensuring all bolted connections are torqued to manufacturer's specifications.
2. Electrical Tests:
a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
C. Remove and replace units that do not pass tests or inspections and retest as specified above.
D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform follow-up infrared scans of transformers at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.07 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.08 CLEANING

A. Clean components according to manufacturer's written instructions.
B. On completion of installation, inspect interior and exterior surfaces and perform the following:

1. Remove paint splatters and other spots.
2. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
3. Repair exposed surfaces to match original finish.

3.09 PROTECTION

A. Temporary Heating: Maintain a clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Apply temporary heating as required.

B. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

END OF SECTION 26 22 00

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

B. Related Sections include the following:
   1. Division 26 Section “Overcurrent Protective Device Studies” for short-circuit rating of devices and for setting of overcurrent protective devices.
   2. Division 26 Section “SPD for Low-Voltage Electrical Power Circuits” for surge protective devices.

1.02 DEFINITIONS

A. DPM: Multi-function Digital-Metering Monitor.
B. EMI: Electromagnetic Interference.
C. GFCI: Ground-fault circuit interrupter.
D. GFEP: Ground-fault equipment protection.
E. MCCB: Molded-case circuit breaker.
F. RFI: Radio-frequency interference.
G. RMS: Root mean square.
H. SPD: Surge protective device.
I. SPDT: Single pole, double throw.
J. SVR: Suppressed voltage rating.
K. VPR: Voltage protection rating.

1.03 PERFORMANCE REQUIREMENTS

A. Overcurrent Protective Device Coordination: All other overcurrent protective devices proposed for inclusion in the Work shall be selected to be coordinated with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency power to 0.10 seconds. Refer to Division 26 Section "Overcurrent Protective Device Studies" for additional requirements.

1.04 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

B. Specification Compliance Certification: Submit a Specification Compliance Certification in accordance with Division 26 Section “Electrical Shop Drawings and Submittals.”

C. Simultaneous Action Submittals: Panelboard Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section “Overcurrent Protective Device Studies.” The release of electrical equipment submittals (panelboards, engine generators, switchboard, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section “Submittal Procedures” to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor’s failure to coordinate simultaneous action submittals will not be considered by the Owner.

D. Product Data: For each type of panelboard, switching and overcurrent protective device, accessory, and related component, include the following:
   1. Manufacturer’s dimensions and technical data on features, performance, electrical characteristics, ratings, and finishes.
   2. Related capacities, features, operating characteristics, furnished specialties, factory settings, accessories and time-current characteristic curves for individual relays and overcurrent protective devices.
      a. Time-current curves for each type of overcurrent protection device. Include hardcopy of characteristic curve and TCC Number for use with Power Tools by SKM Systems Analysis, Inc. Indicate available setting points and selectable ranges for each type of adjustable overcurrent protection device.

E. Shop Drawings: For each panelboard and related equipment, include the following:
   1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
      a. Tabulation of installed devices, equipment features, and ratings.
      b. Enclosure types and details for types other than NEMA 250, Type 1.

c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
e. Bus current and voltage ratings.
f. One-line diagram.
g. Short-circuit current rating of panelboards and overcurrent protective devices.
h. Feeder entry locations and lug configuration.
i. Elevation drawing showing locations for anchor bolts.
j. Nameplate legends.

2. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
3. Wiring diagrams: For each type of panelboard and related equipment, include power, signal, and control wiring.

F. Warranty: Copy of warranty specified in this Section.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified installer.
B. 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.
C. Panelboard Schedules: For installation in panelboards.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Manufacturer's routing maintenance requirements for panelboard and all installed components.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
4. Manufacturer's sample system checklists and log sheets.
B. Warranty: Copy of warranty.

1.07 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer, unless otherwise indicated.
1. Breaker Manufacturer: Manufacturer for breakers shall be the same as the manufacturer of other breakers proposed for other portions of the Work.
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
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 PB 1.
E. Comply with NFPA 70.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.
B. Handle and prepare panelboards for installation according to NEMA PB 1.
C. Handle equipment components according to manufacturer's written instructions. Use factory-installed lifting provisions.
D. Prepare equipment for shipment.
1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.
E. Installation Pathway: Coordinate delivery of equipment to allow movement into designated space.
1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
2. Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.
F. Store equipment indoors in clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.09 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
   b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace panelboard devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by Square D, Schneider Electric. The following manufacturer's may be submitted as an alternate:

1. ABB (General Electric Company); Industrial Connections & Solutions, LLC.
2. Cutler-Hammer, Inc.; Eaton Corporation.
3. Siemens Energy & Automation, Inc.

2.02 RATINGS

A. Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system, unless otherwise indicated.

B. Nominal System Voltage: As indicated on the Drawings.

C. Main-Bus: Amperage as indicated on the Drawings. Provide continuous rating across entire length of main-bus.

D. Short-Time and Short-Circuit Current: Match rating of highest-rated overcurrent protective device in panelboard assembly.

1. Available Short-Circuit Current: As indicated on the Drawings. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

2.03 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Mounting height of breakers shall be in accordance with NFPA 70 requirements. Fabrication of equipment shall take housekeeping pad dimension into account in determining height of top breaker in all sections. Refer to Division 26 Section "Hangers and Supports for Electrical Systems" for housekeeping pad specifications.

B. Enclosures: Surface-mounted cabinets.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
2. Height: 84-inches maximum.
3. Front Cover: Provide the following, unless otherwise indicated:
   a. Hinged Front Cover: Door-in-Door construction with entire front trim hinged to box and with standard door within hinged trim cover to access device handles.
4. Finishes:
   a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Galvanized steel.
5. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Panelboard interior assembly shall be dead front with panelboard front removed. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards served from K-rated or harmonic-mitigating transformers. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

E. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: Ten percent.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on the panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50 deg C rise above ambient. Heat rise tests shall be conducted in accordance with UL 67. The use of conductor dimensions will not be accepted in lieu of actual heat tests.

2.04 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.
B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 48inches high, provide two latches, keyed alike.

C. Main Overcurrent Protection Device Type: Circuit breaker.
1. Main OCPD rated less than 250 Amps: Thermal-Magnetic Circuit Breakers.
2. Main OCPD rated 250 Amps and greater: Electronic Trip-Unit Circuit Breakers.
3. Main OCPD for Emergency Systems or Legally Required Standby Systems: Electronic Trip-Unit Circuit Breakers.

D. Feeder Overcurrent Protection Device Type: Provide overcurrent device as follows, unless otherwise indicated: Circuit breaker.
1. Feeder OCPD rated less than 250 Amps: Thermal-Magnetic; Bolt-on circuit breakers.
2. Feeder OCPD rated 250 Amps and greater: Thermal-Magnetic**;** Bolt-on circuit breakers or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
3. Feeder OCPD for Emergency Systems or Legally Required Standby Systems: Electronic Trip-Unit Circuit Breakers.

E. Branch Overcurrent Protection Device Type: Provide overcurrent device as follows, unless otherwise indicated: Circuit breaker.
1. Branch OCPD rated less than 125 Amps: Bolt-on Thermal-Magnetic circuit breakers.
2. Branch OCPD rated 125 Amps and Greater: Bolt-on Thermal-Magnetic circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between “ON” and “OFF”. Provisions for additional breakers shall be such that no additional connectors will be required to add breakers.

G. Surge Protection Device: Where indicated on Drawings. IEEE C62.41-compliant, externally mounted, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules,

short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.

2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type. Panelboards shall be of the dead-front, quick-make, quick-break, bolt-on circuit breaker type.

B. Main Overcurrent Protection Device Type: Circuit breaker or lugs only.
   1. Main OCPD rated less than 250 Amps: Thermal-Magnetic Circuit Breakers.
   2. Main OCPD rated 250 Amps and Greater: Thermal-Magnetic Circuit Breakers.
   3. Main OCPD for Emergency Systems or Legally Required Standby Systems: Electronic Trip-Unit Circuit Breakers.

C. Branch Overcurrent Protective Devices: Thermal-Magnetic; Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

E. Surge Protection Device: Where indicated on Drawings. IEEE C62.41-compliant, externally mounted, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.

2.06 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Electronic Trip Circuit Breakers: RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
   3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip). Provide as indicated and as required by NFPA 70 for personnel protection.
   4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Breaker handle indicates tripped status.
      c. UL listed for reverse connection without restrictive line or load ratings.
      d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
      e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
      f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
      g. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
      h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.

2.07 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic cover.
   1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.08 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
D. Examine roughing-in of conduits to verify the following:
1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
E. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met.
F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION
A. Install panelboards and accessories according to NEMA PB 1.1.
B. Panelboards with circuit breakers installed before the building has been completed and cleaned shall be masked.
C. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
E. Mount top of trim 74 inches above finished floor unless otherwise indicated. Panelboards of extra height shall be installed at least 18 inches above floor.
F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
G. Install overcurrent protective devices and controllers not already factory installed.
1. Set field-adjustable, circuit-breaker trip ranges.
H. Install filler plates in unused spaces.
I. For Recessed Panels: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade. Paint trim to match wall.
J. Arrange conductors in gutters into groups and bundle and wrap with wire ties. All wiring shall be properly formed; no splices are permitted in gutters.
K. Comply with NECA 1.

3.03 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
B. Panelboard Directory: Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable. A directory of each panelboard shall be completed and available for review by Engineer during final punch list inspection. Provide description of load and location (i.e. “Lighting, East Wall, Room 101”).
C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 CONNECTIONS
A. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.
B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.05 FIELD QUALITY CONTROL
A. Perform tests and inspections.
~~1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.~~
B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. 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 panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Perform follow-up infrared scans of panelboards at 11 months after Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 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."

3.07 CLEANING

A. Clean components according to manufacturer's written instructions.

B. All dust and debris shall be removed from the panels before they are energized and placed into service.

C. All panelboard fronts shall be omitted until final punch list inspection is conducted. Prior to installation of front trim and cover plates inspect interior surfaces and perform the following:
   1. Remove paint splatters and other spots.
   2. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

D. On completion of front trim and cover installation, inspect exterior surfaces and perform the following:
   1. Remove paint splatters and other spots.
   2. Remove all temporary markings and labels.
   3. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

E. Repair exposed surfaces to match original finish.

3.08 PROTECTION

A. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

END OF SECTION 26 24 16

SECTION 26 43 13 - SPD FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes field-mounted SPD for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:

1. Division 26 Section “Panelboards” for field-installed SPDs.

1.02 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. I-nominal: Nominal discharge current.

C. MCOV: Maximum continuous operating voltage.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SVR: Suppressed voltage rating.

H. SPD: Surge Protective Device(s), both singular and plural; also, transient voltage surge suppression.

I. VPR: Voltage protection rating.

1.03 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section “Electrical Shop Drawings and Submittals” for products specified under PART 2 - PRODUCTS.

B. Specification Compliance Certification: Submit a Specification Compliance Certification in accordance with Division 26 Section “Electrical Shop Drawings and Submittals.”

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

1. Include rated capacities, clamp times, physical construction, operating weights, electrical characteristics, furnished specialties, and accessories. Include UL 1449, 3rd Edition Listing documentation verifying:

a. Short Circuit Current Rating (SCCR).

b. Voltage Protection Ratings (VPRs) for all modes.

c. Maximum Continuous Operating Voltage rating (MCOV). The MCOV shall be a tested value per UL 1449 3rd Edition, section 37 .7 .3. MCOV values based solely on the components used in the construction of the SPD will not be accepted.

d. I-nominal rating (I-n).

e. Type 1 or Type 2 Device Listing.

f. kA rating per phase.

g. kA rating per mode.

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, I nominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

3. Copy of test reports from a recognized independent testing laboratory, capable of producing 200kA surge current waveforms, verifying the suppressor components can survive published surge current rating on a per mode basis using the ANSI/IEEE C62.41 impulse waveform C3 (3 x 20 microsecond, 20kV/10kA). Test data on an individual module is not acceptable.

4. Provide written test report showing the SPD can survive a single surge at its rated value without the use of circuit breakers or fuses. Single surge ratings based on the sum of components used in the construction of the SPD will not be acceptable.

D. Warranty: Special warranty specified in this Section.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Certificates: For SPD devices, from manufacturer.

C. Field quality-control reports.

D. Sample Warranty: For manufacturer’s special warranty.

1.05 CLOSEOUT SUBMITTALS

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

B. Warranty: Copy of special warranty.

1.06 QUALITY ASSURANCE

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

B. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

C. Comply with NEMA LS 1.

D. Comply with UL 1449, 3rd Edition.

E. Comply with NFPA 70.

1.07 PROJECT CONDITIONS

A. Service Conditions: Rate SPD devices for continuous operation under the following conditions unless otherwise indicated:
   1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
   2. Operating Temperature: 30 to 120 deg F.
   3. Humidity: 0 to 85 percent, noncondensing.
   4. Altitude: Less than 20,000 feet above sea level.

1.08 COORDINATION

A. Coordinate location of field-mounted SPD devices to allow adequate clearances for maintenance.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Fifteen (15) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PANELBOARD SUPPRESSORS (TYPE B)

A. Basis of Design Product: Subject to compliance with requirements, provide products by Current Technology “TG3” Series (ABB Power Protection) or comparable product by one of the following with prior approval:
   1. ACT Communications, Inc.
   2. United Power Products; Danaher Power Solutions.
   3. Liebert Corporation; a division of Emerson Network Power.

B. Surge Protection Devices:
   1. Comply with UL 1449 4th Edition, Type 1.
   2. LED indicator lights for power and protection status.
   3. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   4. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   5. Audible alarm, with silencing switch, to indicate when protection has failed.
   6. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   7. Four-digit transient-event counter set to totalize transient surges.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 150 kA. The peak surge current rating shall NOT be the arithmetic sum of the ratings of the individual MOVs in a given mode. Manufacturer shall provide independent third party testing validating unit is capable of surviving a single surge at the specified rating.

D. Comply with UL 1283 with a maximum attenuation of 34 dB based on 50 ohm insertion loss test per MIL-STD-220B.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, 3-phase, 4-wire circuits shall not exceed the follows:
   1. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
   2. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
   3. Neutral to Ground: 1000 V for 480Y/277 V and 700 V for 208Y/120 V.
   4. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

F. SCCR: Equal or exceed 200 kA.

G. I nominal Rating: 20 kA

2.02 ENCLOSURES

A. Indoor Enclosures: NEMA 250 Type 1.

2.03 CONDUCTORS AND CABLES

A. Power Wiring: SPD shall be equipped with mechanical lugs that can accept up to #2 AWG wire. Conductors between SPD and panelboard shall be “High Performance Interconnect” (HPI) cables with Ultra Low impedance characteristics at 10 kHz and above.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPD devices with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer’s recommended lead length. Do not bond neutral and

ground. If installed lead length must exceed 10-feet, SPD manufacturer shall provide a low impedance cable that improves the installed performance.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.02 FIELD QUALITY CONTROL

~~A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.~~

~~1.~~A. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. Perform tests and inspections.

~~1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.~~

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
3. Complete startup checks according to manufacturer's written instructions.

D. SPD will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.03 SYSTEM TESTING AND STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Upon completion of installation, provide the start-up and testing services of a factory-authorized and factory-trained local service representative. The tests shall include:

1. Off-line Testing: Impulse injection to verify the system tolerances as well as verification of proper facility neutral-to-ground bond. Compare field test results to factory benchmark test parameters supplied with each individual unit.
2. On-line Testing: Verify that suppression and filtering paths are operating with 100% protection as well as verification of proper facility neutral-to-ground bond by measuring neutral-to-ground current and voltage and by visual inspection.
3. Voltage measurement from Line-to-Ground (L-G), Line-to-Neutral (L-N), Line-to-Line (L-L), and Neutral-to-Ground (N-G), taken at the time of the testing procedure.

C. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.

D. Do not energize or connect service entrance equipment or panelboards to their sources until SPD devices are installed and connected.

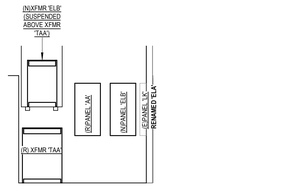
3.04 DOCUMENTATION AND REPORTING

A. Record results of field testing and compare to factory benchmark test parameters supplied with each individual surge protective device. Indicate that the integrity of neutral-to-ground bonds were verified through testing and visual inspection, and that grounding bonds were observed to be in place.

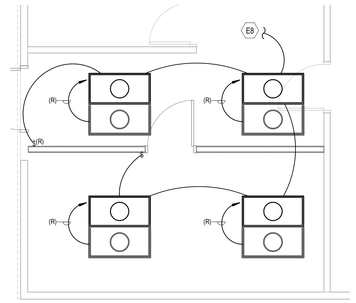
B. Submit to the Engineer copies of the startup test results and the factory benchmark testing results for confirmation of proper suppression filter system function, as required by this section

END OF SECTION 26 43 13


4 MAIN SWITCH YARD - EXISTING CONDITION
NOT TO SCALE




3 ELECTRICAL SECTION - NEW ELECTRICAL ROOM
1/4" = 1'-0"




2 LIGHTING PLAN -CARTS C106
1/4" = 1'-0"


1 ENLARGED ELECTRICAL - MAIN SWITCH YARD & CARTS C106
1/4" = 1'-0"

## GENERAL NOTES (POWER):

A. CONTRACTOR SHALL FOLLOW BRANCH CIRCUITING LAY-OUT, AS INDICATED ON THE FLOOR PLANS, WITH A MAXIMUM OF THREE (3) BRANCH CIRCUITS PER HOMERUN. EACH BRANCH CIRCUIT SHALL BE PROVIDED WITH A DEDICATED NEUTRAL CONDUCTOR. DEDICATED NEUTRAL CONDUCTORS SHALL BE CONSIDERED CURRENT CARRYING.

B. IF ADDITIONAL CONDUCTORS ARE RUN IN THE SAME CONDUIT WITH THOSE INDICATED, CONTRACTOR SHALL DERATE ALL CURRENT CARRYING CONDUCTORS PER NEC 310.15(B)(3), AND UPSIZE CONDUIT AS REQUIRED PER NEC 300.17 AND ANNEX C.

C. MULTIWIRE BRANCH CIRCUITS AS DEFINED IN NEC 100 / 210.4 (CIRCUITS SHARING A COMMON NEUTRAL CONDUCTOR) SHALL NOT BE PERMITTED.

D. IDENTIFY THE PANEL AND CIRCUIT NUMBER FOR ALL RECEPTACLES, SWITCHES, ETC. IN AREA OF CONSTRUCTION. PROVIDE CLEAR ADHESIVE LABELS WITH BLACK LETTERING ON OUTSIDE OF COVER PLATE. MARK INSIDES OF ALL DEVICE BOXES WITH PANEL AND CIRCUIT NUMBER.

E. LOCATIONS OF ELECTRICAL CONNECTIONS AND LOCAL DISCONNECTS SHALL BE COORDINATED WITH MECHANICAL AND PLUMBING CONTRACTORS TO ENSURE ACCESS AND WORKING CLEARANCE IS MAINTAINED PER NEC. NOTIFY OTHER TRADES OF REQUIRED CLEARANCE AREAS TO AVOID ROUTING OF OTHER SYSTEMS IN THESE AREAS. DO NOT INSTALL ELECTRICAL EQUIPMENT OVER EQUIPMENT NAMEPLATES OR ACCESS PANELS OR THROUGH ACCESS/MAINTENANCE CLEARANCES OF EQUIPMENT BY OTHER TRADES.

| TAGGED NOTES | ## |
|---|---|
| E2 | RE-USE EXISTING WIREWAY (ABOVE PANEL) TO INTERCEPT EXISTING FEEDER SERVING PANEL 'HB'. FEEDER SHALL BE EXTENDED TO NEW PANEL 'EHDP'. REFER TO ONE-LINE DIAGRAM ON SHEET JH-E5.1 FOR MORE INFORMATION. EXISTING PANEL 'HB' SHALL BE RENAMED 'EHA'. |
| E3 | INTERCEPT EXISTING FEEDER SERVING PRIMARY SIDE OF EXISTING TRANSFORMER "TLK". FEEDER SHALL BE EXTENDED TO NEW PANEL 'EHDP'. REFER TO ONE-LINE DIAGRAM ON SHEET JH-E5.1 FOR MORE INFORMATION. EXISTING TRANSFORMER 'TLK' SHALL BE RENAMED 'TELA' AND EXISTING PANEL 'LK' SHALL BE RENAMED 'ELA'. |
| E4 | PROVIDE (2) 2" CONDUITS FOR POWER AND (1) 1" CONDUIT FOR CONTROLS FROM GENERATOR TO SERVE AUTOMATIC TRANSFER SWITCH 'ATS-GP' |
| E8 | RECONNECT TO EXISTING LIGHTING CIRCUIT SERVING THIS AREA. |
| E9 | RELOCATE FLUSH MOUNTED LAPTOP AND ASSOCIATED CIRCUIT TO NEW LOCATION INDICATED. LAPTOP SHALL FACE OUT IN HALLWAY ACCESSIBLE TO STAFF. |
| E10 | PROVIDE NEW DOUBLE POLE, DOUBLE THROW DOOR CONTACTS AT NEW DOOR TO CONNECT TO EXISTING BUILDING INTRUSION SYSTEM. |
| E12 | LAND RELOCATED CIRCUITS TO THIS PANEL FROM EXISTING PANEL AS INDICATED ON PANEL SCHEDULES |
| E13 | CIRCUITS ON THIS PANEL SHALL BE REMOVED AND RELOCATED TO EMERGENCY PANEL AS INDICATED ON THE PANEL SCHEDULES. |

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# Roy J. Wollam Elementary School and Santa Fe Junior High School - Generator Installation

4132 Warpath Ave., Santa Fe, TX 77510

SANTA FE INDEPENDENT SCHOOL DISTRICT


04/08/2022

Revision Schedule

| NO. | ISSUE | DATE |
|---|---|---|
| | | |
| 1 | Addendum #1 | 04/08/2022 |

| Sheet Information | |
|---|---|
| Date | 04-08-2022 |
| Job Number | 22-002 |
| Drawn | TMZ |
| Checked | GJG |
| Approved | GJG |

CMTA
CONSULTING ENGINEERS
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2201 TIMBERLOCH PL. SUITE 110
THE WOODLANDS, TX 77380
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Title

ENLARGED ELECTRICAL PLAN - GENERATOR

Sheet

JH-E4.0

Construction Documents