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UNIVERSITY OF LOUISVILLE
SPECIAL CONDITIONS OF THE CONTRACT
FOR CONSTRUCTION BY A GENERAL CONTRACTOR
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ARTICLE 01 GENERAL INFORMATION

- 1.1 These Special Conditions are intended to modify, supplement, or delete from, applicable Articles of the General Conditions.
- 1.2 Where any Article of the General Conditions is supplemented by these Special Conditions, the Article shall remain in effect and the supplement shall be added thereto.
- 1.3 Where Special Conditions conflict with General Conditions, provisions of the Special Conditions take precedence.

ARTICLE 02 FIELD CONDITIONS

- 2.1 General Contractor will secure all data at the site of the building such as grades of lot, convenience of receiving and sorting material, location of public services, and other information which will have a bearing proposals or on the execution of the Work and shall address these issues in the preparation of their bid. No allowance shall be made for failure of the General Contractor to obtain such site information prior to submitting their proposal, and no adjustment to the General Contractor's Contract amount or stipulated time for completion shall be allowed when due to failure by the General Contractor to do so.

ARTICLE 03 – Not Applicable

ARTICLE 04 CONSULTANT

- 4.1 Wherever in these Contract Documents reference is made to the Consultant, it shall be understood to mean KFI Engineers or their duly authorized representatives. (See Article 2 of the General Conditions.)

ARTICLE 05 GEOTECHNICAL REPORT

- 5.1 No subsurface or geotechnical survey information is available at this time.

ARTICLE 06 TIME FOR COMPLETION

- 6.1 The time for Substantial Completion as further defined in Article 1 of the General Conditions shall be 210 consecutive calendar days from the date of commencement as specified in the Work Order letter, and Final Completion shall be thirty (30) days thereafter.

ARTICLE 07 LIQUIDATED DAMAGES

- 7.1 Should the General Contractor fail to achieve Substantial Completion of the Work under this Contract on or before the date stipulated for Substantial Completion (or such later date as may result from extensions in the Contract Time granted by the Owner), he agrees that the Owner is entitled to, and shall pay the Owner as liquidated damages the sum of \$ Three Hundred Sixty-Four Dollars (\$364.00) for each consecutive calendar day that Substantial Completion has not been met. See Article 3 of the Agreement.
- 7.2 Should the General Contractor fail to achieve Final Completion of the Work under this Contract on or before the date stipulated for Final Completion (or such later date as may result from extensions in the Contract Time granted by the Owner), he agrees that the Owner is entitled to, and shall pay the Owner as liquidated damages the sum of \$One Hundred Fifty Dollars (\$150.00) for each consecutive calendar day until Final Completion is reached. See Article 3 of the Agreement.

ARTICLE 08 SUBMITTALS AND SHOP DRAWINGS

- 8.1 SUBMISSIONS - GENERAL

8.1.1 The General Contractor shall submit each set of Shop Drawings, product data and samples as a separate item.

8.1.2 All sample selections for color shall be submitted for approval at the same time. Color selections shall not be submitted individually.

8.1.3 Any deviation from the Contract Documents shall be noted on the transmittal form comment section.

8.1.4 All submittals are to be reviewed by the General Contractor for compliance with the Contract Documents before submission for approval. All submittals are to be initiated by the General Contractor. Submittals made directly to the Consultant by sub-contractors, manufacturers or suppliers will not be accepted or reviewed.

8.1.5 Re-submittals shall conspicuously note all changes from earlier submissions. Special notation by the General Contractor shall be made to any changes other than those in response to the Consultant's review.

8.1.6 Manufacturers shall, when requested by the Consultant, submit test reports prepared by reputable firms or laboratories certifying as to performance, operation, construction, wearability, etc., to support claims made by the manufacturer of the equipment or materials proposed for inclusion in the Work. General Contractor shall also submit a list of three (3) installations where said equipment or materials have been in service for a minimum of five (5) years.

8.2 SUBMISSIONS - REVIEW

8.2.1 Review of submittals is only for compliance with the design concept and the contract documents. THE CONSULTANT SHALL NOT BE RESPONSIBLE FOR CHECKING DEVIATIONS FROM CONTRACT DOCUMENT REQUIREMENTS OR CHANGES FROM EARLIER SUBMISSIONS NOT SPECIFICALLY NOTED.

8.2.2 The following shall be verified prior to making submittals:

Field Measurements, Field Construction Criteria, Catalog numbers and similar data, Quantities and Capacities, and Compliance with requirements, including verification of all dimensions,

8.2.3 Review Stamp designations shall be as follows:

8.2.3.1 "NET = No Exceptions Taken": Proceed with the Work, no corrections needed.

8.2.3.2

"FC= Furnish as Corrected": Proceed with the Work, noting the corrections/conditions of the approval.

8.2.3.3 "RR = Revise and Resubmit": Do not proceed with the Work, as the submittal does not comply with the Contract Documents. Revisions to the submittal are required for approval.

8.2.3.4 "R = Rejected": Do not proceed with the Work, the submittal is rejected.

8.3 SUBMISSIONS - SPECIAL PROVISIONS

8.3.1 In making a submittal, the General Contractor shall be deemed to be making the following representations:

8.3.1.1 The General Contractor understands and agrees that he shall bear full responsibility for the products furnished. The General Contractor expressly warrants that products described in the attached submittal will be usable and that they conform to the Contract requirements unless specifically noted otherwise.

8.3.1.2 The General Contractor understands and agrees that, without assuming design responsibility, he expressly warrants that products described in the attached submittal are capable of being used in accordance with the intent of the design documents and that they conform to the Contract requirements unless specifically noted otherwise.

8.3.1.3 The General Contractor acknowledges that the Owner will rely on the skill, judgment, and integrity of the General Contractor as to conformance requirements and subsequent usability.

8.4 SHOP DRAWING AND PROCUREMENT SUBMITTAL LOG

8.4.1 The General Contractor, within ten (10) days after the Pre-Construction meeting, shall begin uploading submittals to generate a log fixing the dates for submission of Shop Drawings, special order material items, certifications, guarantees, and any other items required to be submitted to the Consultant for review, approval or acceptance.

8.4.2 The log shall track all submittals to date. The updated log shall then be reviewed and discussed at each progress meeting to determine items that may impact the construction schedule.

8.5 Shop Drawings

8.5.1 The General Contractor shall review, approve, and submit Shop Drawings to the Consultant, in accordance with the Consultant's Shop Drawing & Procurement Submittal Log, as herein detailed. By approving and submitting Shop Drawings, the General Contractor represents that he has determined and verified all materials, field measurements, and field construction criteria related thereto, or will do so, and that he has checked and coordinated the information contained within such submittals with the requirements of the Work and of the Contract Documents.

8.5.2 The General Contractor shall submit Shop Drawings required for the Work and the Consultant will review and take appropriate action. The review and approval shall be only for conformance with the design concept of the Project and for compliance with the information given in the Contract Documents. The approval of a separate item will not indicate approval of the assembly in which the item functions.

8.5.3 The General Contractor shall make any corrections required by the Consultant for compliance to the Contract and shall return the required number of corrected copies of Shop Drawings and resubmit new samples until approved. The General Contractor shall direct specific attention, in writing, or on resubmitted Shop Drawings, to revisions other than the corrections called for by the Consultant on previous submissions. The General Contractor's stamp of approval on any shop drawing or sample shall constitute a representation to Owner and Design Consultant that the General Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data, or he assumes full responsibility for doing so, and that he has reviewed or coordinated each shop drawing or sample with the requirements of the Work and the Contract Documents.

8.5.4 Where a shop drawing or sample submission is required by the specifications, no related Work shall be commenced until the submission has been approved by the Design Consultant. A copy of each approved shop drawing and each approved sample shall be kept in good order by the General Contractor at the site and shall be available to the Consultant.

8.5.5 The Consultant's approval of Shop Drawings or samples shall not relieve the General Contractor from his responsibility for any deviations from the requirements of the Contract Documents unless the General Contractor has in writing called the Consultant's attention to such deviation at the time of submission and the Consultant has given written approval to the specific deviation. Any approval by the Consultant shall not relieve the General Contractor from responsibility for errors or omissions in the Shop Drawings.

8.5.6 All submittals are to be submitted electronically by the contractor. Each individual Shop Drawing shall have its respective specification number and description highlighted.

8.5.7 Where Shop Drawings include fire alarm, communication systems schematics, sprinkler systems, etc., a mylar sepia of each drawing shall be submitted to the Consultant as part of the "Record" set of drawings.

8.6 SUBMISSIONS - SAMPLES

8.6.1 Office samples shall be of sufficient size and quantity to clearly illustrate functional characteristics of the product with integrally related parts and attachment devices, and full range of color, texture, and pattern.

8.6.2 Products shall not be used until the sample has been submitted to and approved by the Consultant.

8.6.3 A minimum of two (2) samples are required to be submitted to the Consultant for review and approval and will be distributed as follows:

- a) One (1) to be retained by the University.
- b) One (1) to be returned to the Design Consultant.
- c) An additional sample or samples may be submitted, at the General Contractor's option, for distribution to a third party.

8.6.4 Field samples (block, brick, etc.) of materials to be constructed at the site shall be submitted for review as required by the individual section of the Contract Documents.

8.7 SUBMISSIONS - OPERATION AND MAINTENANCE MANUALS

8.7.1 The University requires a minimum of two (2) bound copies and one (1) digital copy of the final installation, training, operation, maintenance, and repair manuals to be turned over to the Owner's Project Manager and approved for content by the Consultant by or before the time construction is 75% complete.

8.7.2 Manuals provided must be of sufficient detail to enable the Owner or others to install, calibrate, train, operate, maintain, service and repair every system, subsystem, and/or piece of equipment installed on or as part of this Contract. Each manual must contain:

8.7.2.1 Project Title, Project number, Location, dates of submittals, names, addresses and phone number for the Consultant, General Contractor, and General Contractor's Sub-contractors.

8.7.2.2 An Equipment Index that includes vendor's names, addresses, and telephone numbers for all equipment purchased on the Project.

8.7.2.3 Emergency instructions with phone numbers and names of contact persons on warranty items shall be provided.

8.7.2.4 Original copies of the following provided by the manufacturer:

Installation Manuals	Instruction Manuals
Training Manuals	Operation Manuals
Service Manual	Repair Manuals
Parts List	Wire List
Reviewed Shop Drawings	

8.7.2.8 Any Computer, Micro controller, and/or Microprocessor equipped equipment installed shall be provided with source code copies of all software and firmware (prom, EPROM, ROM, other) supplied on this Contract; and

8.7.2.9 Copies of all inspection and guarantee certificates, manufacturers' warranties with the University of Louisville listed as the Owner for all equipment provided and/or installed.

8.7.2.10 All manuals shall be as follows: Bound in hard cover three (3) ring (D-type) binder, 1", 1.5" or 2" maximum, indexed and in CSI format, tabbed (4,5,8 or 16th cut), no more than 80% binder fill, white vinyl,

presentation type with clear vinyl view cover on front, back and spine and with pockets on front and back. Maximum drawing size in binder shall be folded 11"x17" and shall be hole punched and reinforcements added. Do not put drawings in pockets. Top of all drawings shall be at top or spine side of the manual. Complete drawings must be viewed without opening rings. Provide binders as manufactured by Universal Office Products, Des Plaines, IL. 1"(S# B2-20742), 1.5"(B2-20744), or 2"(B2-20746) or equal.

8.7.2.11 If the binder includes manuals from any single vendor covering several different model numbers, the model used on the Project must be highlighted.

8.7.2.12 Included in the front of the "Operation and Maintenance Manual" shall be a copy of the Interior and Exterior Finish plan and Schedule listing all finish materials, the manufacturer, the finish color, and the manufacturer's paint number.

8.7.2.13 Photograph album containing photos and negatives or digital images on CD (.pdf format) showing buried utilities and concealed items shall be included.

8.8 SUBMISSIONS – AS - BUILT SET OF DRAWINGS

8.8.1 The General Contractor shall submit one (1) electronic copy of As - Built set of drawings in .pdf format and one (1) hard copy indicating all deviations of construction as originally specified in the Contract Documents. These As-Built Drawings will compile information from the General Contractor as well as all Sub-contractors. The General Contractor shall provide a qualified representative to update the As - Built set of drawings as construction progresses.

8.8.2 The General Contractor shall provide and utilize a camera to photograph the installation of buried utilities and concealed items. The General Contractor shall provide standard 3 1/2" x 5" photographs with negatives, or digital images on CD (.jpeg format), which shall be submitted as part of the Operation and Maintenance Manuals submission. These photos should be mounted in a bound album with labeling as to subject of photo, date, and Project. Such album is to be kept at job site with the As - Built set of drawings until submittal of same.

8.8.3 Approval of the Final Payment request will be contingent upon compliance with these provisions. The General Contractor's As – Built set of drawings shall be delivered to the Consultant at their completion so that the Consultant may make any changes on the original contract drawings.

ARTICLE 09 PLANS, DRAWINGS, AND SPECIFICATIONS

9.1 The University will provide two (2) sets of the 'Official Contract Documents' to the successful General Contractor. One (1) set is to be for his office and the other set is for the jobsite.

9.2 All drawings, specifications and copies thereof, prepared by the Consultant, are the property of the University of Louisville. They are not to be used on other Work.

ARTICLE 10 PROGRESS MEETINGS

10.1 In addition to specific coordination and pre-installation meetings for each element of Work, and other regular Project meetings held for other purposes, progress meetings will be held as outlined at the Preconstruction Meeting. Each entity then involved in planning, coordination or performance of Work shall be properly represented at each progress meeting. The following areas will be covered at each progress meeting: current status of work in place; GENERAL CONTRACTOR's review of upcoming work (1 month look ahead); schedule status; upcoming outages; new outage requests; shop drawings due from Sub-contractors; shop drawings being reviewed; outstanding RFIs; outstanding RFQs; new RFQs; change orders pending approval; new business; As-Built updated; close-out documents status; defective work in place issues; review of "pencil copy" of payment application; safety issues; and new business or other issues not covered above. With regard to schedule status, discuss whether each element of current work is ahead of schedule, on time, or behind schedule in relation with updated progress schedule; determine how behind-schedule Work will be expedited, and secure commitments from entities involved in doing so; discuss

whether schedule revisions are required to ensure that current Work and subsequent Work will be completed within Contract Time; and review everything of significance which could affect the progress of the Work.

10.2 General Contractor shall prepare and submit at each progress meeting an updated schedule indicating Work completed to date and any needed revisions.

10.3 With the express purpose of expediting construction and providing the opportunity for cooperation of affected parties, progress meetings will be held and attended by representatives of:

- (1) The Owner's Project Manager
- (2) The Consultant.
- (3) General Contractor.
- (4) Sub-contractors.
- (5) Physical Plant Division Representative

10.4 A location near the site will be designated where such progress meetings will be held. Participants will be notified of the dates and times of the meetings by the Consultant.

ARTICLE 11 CONSTRUCTION SCHEDULE – BAR CHART

11.1 The General Contractor shall prepare construction schedules as a bar chart, with separate divisions for each major portion of the work, and in sufficient detail to identify the plan and sequence of construction to be followed in meeting the requirements of the Contract. Schedules shall include divisions for Work to be accomplished remote from the central construction site, e.g. utilities from outside the construction site to the site for chilled water, steam, electrical, communications, and/or fire service. Such Work shall be scheduled so that disruption resulting from construction will be minimized. Start dates and completion dates for such Work must be maintained and completed in the shortest reasonable time. The sequence of listings shall follow the Table of Contents of the Specifications. Maximum sheet size shall be 30" x 42". The schedule shall show the complete sequence of construction, by activity, with dates for beginning and completion of each element of the Work.

11.1.1 For projects requiring a bar chart schedule instead of a Critical Path Method (CPM) schedule, the following Articles of the General Conditions are amended as follows:

11.1.2 Article 21.4.2 of the General Conditions to the Contract is amended to read as follows:

21.4.2 Requests for an extension of time due to unusually bad weather shall be considered for approval only if it is shown that the unusual weather event delayed work on a specific weather sensitive activity or activities that had been planned to be underway on the date(s) on which the weather event occurred, as shown in the most recent update to the Project schedule that had been submitted to the Owner prior to the date of the event and that the delay to that activity or activities is shown to be the proximate cause of a corresponding delay to the projected date for Substantial Completion of the Project that was shown in the most recent update to the Project schedule. The actual dates on which the delay(s) occurred must be stated and the specific activities that were directly impacted must be identified. In the event of concurrent delays, only those activities actually impacting the Project Substantial Completion date will be considered in evaluating the merit of a delay request and in adjusting the schedule. Time extensions will not be considered if such adjustments do not exceed the total or remaining "float" associated with the impacted activities at the time of delay, nor for concurrent delays not caused by the Owner. Requests for an extension of time which are not supported by this information shall not be considered for approval by the Owner.

11.1.3 Article 21.4.3 of the General conditions to the Contract is amended to read as follows:

21.4.3 In anticipation of the possibility of delay due to unusual inclement weather, the General Contractor shall identify those activities in the schedules, and those activities subsequently added to updated schedules, that might reasonably be expected to be delayed by inclement weather.

11.1.4 Article 21.8 of the General Conditions to the Contract is amended to read as follows:

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21.8 The Contract Time will only be adjusted for causes specified above. Extensions of time will only be approved if the General Contractor can provide justification supported by the Project schedule or other acceptable data that such changes extend the contractually required date of Substantial Completion, and that the General Contractor has expended all reasonable effort to minimize the impact of such changes on the construction schedule. No additional extension of time will be granted subsequently for claims having the basis in previously approved extensions of time.

11.1.5 Article 32.1 of the General Conditions to the Contract is amended to read as follows:

32.1 The General Contractor shall prepare and submit to the Owner and the Consultant a bar-chart type construction schedule for the Work. The schedules shall include all activities necessary for performance of the work showing the duration and the planned start and finish dates for each activity. The schedules shall include, but not be limited to, submittal processing, fabrication and delivery of materials, construction, testing, clean-up, work and/or materials to be provided by the Owner, dates and durations for major utility outages requiring coordination with the Owner and the Owner's operations, and significant milestones related to the completion of the Project.

11.2 The schedule shall be submitted to the Consultant and to the Owner for review within thirty (30) calendar days after the date established for the start of Work on the Project as stated in the official Work Order and Notice to Proceed. Review will be only for general conformance to the requirements of the contract. Review comments and/or acceptance of the Contractor's schedule shall not relieve the Contractor of any obligation for compliance with all requirements of the Contract Documents. Such review and comments shall not constitute interference with the Contractor's means and methods of construction, which shall remain solely the responsibility of the Contractor.

11.3 Schedules shall be revised no less frequently than monthly to coincide with regular monthly Project progress meetings and submission of Applications for Payment and shall be updated to indicate progress of each activity to the date of submittal, the projected completion of each activity, any activities modified since previous submittal, any major changes in scope, and all other identifiable changes, and further shall be accompanied by a narrative report to define problem areas, anticipated delays, impact on the progress of the Work, and to report corrective action taken or proposed.

11.4 Initial schedules shall be submitted within thirty (30) calendar days after the date established in Notice to Proceed. After review, required revisions to the schedule shall be completed and incorporated in the schedule within ten (10) calendar days. Up-dated Progress Schedules shall be submitted with each Application for Payment. Submissions must include one (1) opaque reproduction and one (1) electronic copy (disk or CD) along with a transmittal letter.

11.5 Copies of reviewed Schedules are to be provided to the job site file and, as appropriate, to sub-contractors, suppliers, and other concerned entities, including separate contractors. Recipients are to be instructed to promptly report, in writing, problems anticipated by projections shown in schedules.

11.6 The processing of all progress payments is contingent upon the submission of updated schedules.

11.7 The processing of all Change Orders requesting a time extension to the contract are contingent upon the submission and approval of a revised schedule demonstrating that the change order does impact the date of completion for the entire project. Time extension requests associated with Change Orders that do not impact the date of completion for the entire project will be rejected.

ARTICLE 12 WALK-THROUGH

12.1 After the "Work Order" is issued but before Work by the General Contractor is started, a walk-through of the area is required to document the condition of the space, surfaces, or equipment. It is the responsibility of the General Contractor to schedule the walk-through with the Owner's Project Manager, the Consultant, and other interested parties.

12.2 During the walk-through, General Contractor shall identify all damaged surfaces or other defective items that exist prior to construction.

12.3 The walk-through shall be attended by Owner's Project Manager, a Representative of the user of the facility, the General Contractor and the Consultant

12.4 Written documentation of the walk-through is to be provided by the Consultant with copies distributed to all parties. Polaroid type color photographs are to be provided and labeled by General Contractor and one (1) copy of such photographs are to be given to Consultant. (Digital photos in a .jpg format are acceptable if submitted on a CD) All parties attending the walk-through agree on the list of damages.

ARTICLE 13 OWNER'S CONSTRUCTION REPRESENTATIVE – Not Applicable

ARTICLE 14 FIELD OFFICE – Not Applicable

ARTICLE 15 TELEPHONE SERVICE – Not Applicable

ARTICLE 16 CONSTRUCTION FENCE – Not Applicable

ARTICLE 17 PROJECT SIGN – Not Applicable

ARTICLE 18 PARKING

18.1 The University of Louisville will make available for purchase by the General Contractor up to four (4) parking permits. The category of parking permit and location of parking is determined by the Director, Parking and Transportation Services, or a designee. Parking permits may be purchased by the General Contractor to be used by the Contractor and/or the Contractor's subcontractors and employees during the construction period.

ARTICLE 19 SANITARY FACILITIES

19.1 Restroom facilities in one of the surrounding buildings will be designated at the Pre-Construction Meeting for use by the General Contractor's workforce during construction. The designated restroom(s) and areas accessible to General Contractor must be kept clean and neat during construction. Failure to keep them clean will result in the General Contractor being required to provide portable toilets at his cost at the site. Drinking water shall be provided from an approved safe source so piped or transported as to be kept clean and fresh and served from single service containers or satisfactory types of sanitary drinking stands or fountains. All such facilities and services shall be furnished in strict accordance with existing governing health regulations.

ARTICLE 20 RULES OF MEASUREMENT

20.1 Rules of Measurement shall be established by the Consultant in the field. Actual measurement shall be taken in the field. These amounts shall become binding upon the General Contractor and be adjusted as before mentioned.

20.2 The General Contractor shall pay for and coordinate through the Consultant and/or the Owner's Project Manager all associated Work by utility companies including relocation of utility poles, installation of new street lights, relocation of overhead or underground lines, and any other Work called for on the Plans and in the Specifications.

ARTICLE 21 ALLOWANCES

21.1 As stated in the General Conditions to the Contract, the General Contractor shall have included in the Contract Amount all costs necessary to complete the Work. The contractor shall also include \$20,000.00 for painting the existing Electrical Rooms in 55a and 55b. This amount does not include contractor markup. Any markup will need to be included by the contractor and it will be in addition to the \$20,000.00.

ARTICLE 22 SEQUENCE OF CONSTRUCTION

22.1 The project shall be constructed in a single phase, with the following milestone dates: TBD

22.2 All materials and equipment are to be brought into the project site from the approved staging location and are not to be brought through the existing buildings or loading docks. Any and all exceptions shall be approved by, and closely coordinated with, the Owner's Project Manager in advance of scheduling or performing the work.

22.2.1 The General Contractor shall coordinate any road and sidewalk closings, utility disruptions, etc. which will affect the use of the existing building(s) with the Owner's Project Manager prior to commencing that Work.

22.3 The adjacent buildings and public areas will remain in use and the Owner shall have access to the existing building(s) throughout the duration of the Project. The General Contractor shall coordinate construction activity to assure the safety of those who must cross the Project site and shall provide and maintain the necessary barriers and accommodations for a completely safe route of accessibility. The General Contractor is to ensure that all exits provide for free and unobstructed egress. If exits must be blocked, prior arrangements must be made with the Owner's Project Manager.

22.4 The General Contractor shall cooperate with the Owner to minimize inconvenience to, or interference with normal use of existing buildings and grounds by staff, students, other Contractors, or the public. General Contractor shall conduct operations to prevent damage to adjacent building structures and other facilities and in such a manner to protect the safety of building's occupants.

22.5 Special effort shall be made by the General Contractor to prevent any employee from entering existing buildings for reasons except construction business. In particular, use of toilets, drinking fountains, vending machines, etc. is strictly prohibited.

ARTICLE 23 CRANE & MATERIAL HOIST OPERATIONS

23.1 General Contractor shall provide appropriate barriers around crane and material hoist to protect pedestrian- and vehicular traffic around operating area. When crane is operating or moving, flag men provided by General Contractor shall be utilized to prevent pedestrian and vehicular traffic from crossing the pathway of crane lift. General Contractor's flag men shall coordinate these activities with the appropriate security personnel.

23.2 Cranes and material hoists shall be safely secured and inaccessible during non-operating hours. General Contractor shall coordinate operation or erection of a crane or material hoist in the vicinity of the Medical Center with Medical Center Aeromedical Operations (Med-evac helicopter).

23.3 Any damage to trees, shrubs or plant material at the placement of crane or material hoist shall be repaired by tree surgery or replaced as directed by Consultant.

ARTICLE 24 UTILITIES

24.1 This Article modifies Article 8 of the General Conditions. The Owner will provide water and electricity for this Project. The General Contractor shall provide for all temporary taps, hoses, lines, boxes, lighting and installation of the same for construction operations. Electricity shall not be used for heating purposes. In the event that the General Contractor is wasteful with these utilities, the Owner shall charge the General Contractor accordingly.

24.2 UTILITY OUTAGES

24.2.1 Interruption of Utilities and Services: No utilities or services may be interrupted without full consent and prior scheduling of the Owner. Owner approval is required in writing for each disruption.

24.2.1.1 ENTIRE BUILDING OUTAGE

The Owner's Project Manager is the General Contractor's contact with the University for requesting Utility Outages. The Owner's Project Manager will contact the proper departments and divisions within the University and receive approval from those units prior to allowing a planned outage to occur. The established standard within the University Departments and Divisions of an entire building or group of buildings shall be three weeks written notice. The written notice shall include the type of utility to be interrupted, reason for outage, length of outage, what will be affected by the outage and a statement of whether or not the materials are on hand to complete the Work. If a specific time is desired for the outage it should be included. The Owner's Project Manager will insure that all parties affected are contacted and that a time which is least disruptive to all parties is selected. At the appointed outage time, Work shall begin and proceed continuously with all required manpower until Work is complete at no added cost to the University. The Owner's Project Manager will then notify all affected departments or divisions.

24.2.1.2 SECTION OF A BUILDING OUTAGE

The Owner's Project Manager is the General Contractor's contact with the University for requesting Utility Outages. The Owner's Project Manager will contact the proper departments and divisions within the University and receive approval from those units prior to allowing a planned outage to occur. The established standard within the University Departments and Divisions of a section of a building shall be a written request one week prior to outage. The written request shall include the type of utility to be interrupted, when the outage is desired, reason for outage, length of outage, and what will be affected by the outage. The Owner's Project Manager will insure that all parties affected are contacted and that a time which is least disruptive to all parties is selected. At the appointed outage time Work shall begin and proceed continuously with all required manpower until Work is complete at no added cost to the University. The Owner's Project Manager will then notify all affected departments or divisions.

ARTICLE 25 CLEANING AND TRASH REMOVAL

25.1 The General Contractor shall keep clean the entire area of new construction and shall keep streets used as access to and from the site free of mud and debris.

25.2 All exit ways, walks, drives, grass areas, and landscaping must be kept free from debris, materials, tools and vehicles at all times. Trim weeds and grass within the site area.

25.3 Upon completion of the Work, General Contractor shall thoroughly clean and re-sod grass areas damaged to match existing areas.

25.4 The General Contractor shall be responsible for removal from the site of all liquid waste or other waste (i.e. hazardous, toxic, etc.) that requires special handling on a daily basis.

25.5 Dumpsters will be provided and maintained by the General Contractor.

25.6 During Work at the Project site, the General Contractor shall clean and protect Work in progress and adjoining Work on a continuing basis. General Contractor shall apply suitable protective covering on newly installed Work where needed to prevent damage or deterioration until the time of Substantial Completion. General Contractor shall clean and perform maintenance on newly installed Work as frequently as necessary through remainder of construction period.

25.7 The General Contractor shall be responsible for daily cleaning of spillage's and debris resulting from his and his Sub-contractor's operations, (includes removal of dust and debris from wall cavities), and for providing closed, tight fitting (dustproof if required), waste receptacles to transport construction debris from the work area to the dumpster. Broom clean all floors no less than once a week. The General Contractor shall empty such receptacles into the trash container when full or when directed to be emptied by the Consultant and/or Owner's Project Manager, but not less than weekly. The use of hospital waste and trash receptacles is strictly prohibited, except as otherwise provided by the project specifications.

25.8 Failure to comply with the above requirements shall be cause for stopping work until the condition is corrected.

ARTICLE 26 BLASTING – Not Applicable

ARTICLE 27 CUTTING AND PATCHING - NEW AND EXISTING WORK

27.1 New Work - Cutting and patching shall be done by craftsmen skilled and experienced in the trade or craft that installed or furnished the original Work. Repairs shall be equal in quality and appearance to similar adjacent Work and shall not be obviously apparent as a patch or repair. Work that cannot be satisfactorily repaired shall be removed and replaced.

27.2 Existing Construction - Refer to Architectural, Mechanical, and Electrical drawings for cutting and patching. All new Work shall be connected to the existing construction in a neat and workmanlike manner, presenting a minimum of contrast between old and new Work. Do all patching of the existing construction as may be required for the new construction to be done. Necessary patching, closing of existing openings, repairing and touching up shall be included as required for a proper, neat and workmanlike finished appearance. Any existing item that is to remain and is damaged during construction shall be replaced at the General Contractor's expense.

ARTICLE 28 UNRELATED PROJECTS

28.1 Unrelated construction Projects may be under way in the vicinity of this Project or the site utility work during the course of the Work related to this Project. The General Contractor for this Project must coordinate with any other contractors regarding overlapping areas. See Article 42 - Separate Contracts of the General Conditions.

ARTICLE 30 REMOVED ITEMS

30.1 The following is a list of items to be turned over to the Owner by the General Contractor after removal by the General Contractor. If there are additional items listed in the drawings to be turned over to the Owner, but not listed here, it shall be construed as being listed here.

1. Refer to the Drawings for other Items to be removed, salvaged, or demolished as part of the project.

30.2 All items which are identified to be turned over to the Owner must be treated with the utmost care and protected during removal and transport from damage.

30.3 Materials to be turned over to the Owner by the General Contractor shall be delivered to a warehouse within a five (5) mile radius of the Project site.

ARTICLE 31 INTERIOR ENCLOSURE AND DUST ENCAPSULATION

31.1 Areas under construction or renovation shall be separated from occupied areas by suitable temporary enclosures furnished, erected and maintained by the General Contractor. Temporary enclosures shall be dust and smoke tight and constructed of non-combustible materials to prohibit dirt and air borne dust from entering occupied spaces. General Contractor to review with Consultant ways to provide ventilation for dust generated by demolition and fumes/vapors produced during installation of new materials.

31.2 General Contractor is responsible for coordinating with the Owner's Project Manager any equipment to be turned off prior to erecting temporary enclosures.

31.3 General Contractor shall protect all exhaust diffusers, equipment and electrical devices from the collection of dust. All areas shall be checked and cleaned prior to final acceptance of Work.

31.4 Dust and debris from Work operations shall be held to a minimum.

31.5 General Contractor shall construct temporary dust partitions at locations and as detailed on drawings. Closures used for dust barricade shall be constructed of non-combustible materials, (metal studs and gypsum board or fire-retardant plywood).

SPECIAL CONDITIONS

31.6 General Contractor shall provide additional devices and materials and required to contain dust within Work area and protect personnel during course of Work.

31.7 Areas of minor renovation, consisting of the removal of doors and frames, blocking of openings, and other limited Work shall be separated by a dust partition of fire retarded polyethylene on studs.

31.8 Existing corridor doors may serve as dust barriers, except if removed for refinishing. In such cases, temporary wood doors must be substituted until original doors are replaced.

31.9 The General Contractor may assume existing walls which extend full height, floor to structure, shall be deemed appropriate to contain air borne dust. Cover any voids or penetrations.

31.10 Doors or windows in the perimeter walls surrounding the Project work area shall be sealed off with protective materials in a manner to prohibit dust from escaping the work area. These shall be left in place until all work creating dust is completed. Protective materials shall consist of fire-retardant wood, metal studs, gypsum board or flame resistant plastic.

31.11 Entry passage to Work area shall be sealed off with zippered plastic opening or other acceptable means which allows periodic entry and closure of barricade closure.

31.12 Install and maintain a "sticky mat" on the floor in locations where construction crews leave the construction area and prior to entering ANY existing space in the building.

31.13 Install and maintain a temporary floor covering in any and all elevators being utilized for this project.

ARTICLE 32 COMMUNICATIONS AND NETWORK SYSTEMS – Not Applicable

ARTICLE 33 EMERGENCY VEHICLE ACCESS

33.1 Emergency Vehicle Access must be maintained during construction. The General Contractor shall coordinate with the local Fire and Emergency Medical Services department(s) that would respond to an emergency during the initial start up of construction to ensure a complete understanding of their requirements.

ARTICLE 34 SMOKE DETECTORS / FIRE ALARM SYSTEMS- EXISTING AND/OR NEW FACILITIES

34.1 General Contractor shall protect all smoke detectors in Work areas to prevent false alarms. The General Contractor will be responsible for any false alarm caused by dust created in their Work areas or dust traveling to areas beyond the Work past inadequate protection barriers. If there is a need for an existing or newly installed fire alarm system or parts of that system to be serviced, turned off, or disconnected, prior approval must be obtained from the Owner's Project Manager and notification given to the Campus Dispatch Office. The General Contractor must follow the procedure outlined for Utility Outages and any documented costs charged by the responding fire department due to a false alarm shall be paid by the General Contractor. As soon as all Work is completed, notification must be given to the Owner's Project Manager and to the Campus Dispatch Office prior to reactivation of the system. Prior to Final Payment to the General Contractor, all protected smoke detectors will be uncovered and tested.

34.1.1 When the function of any fire alarm, detection or suppression system is impaired, a temporary system shall be provided. General Contractor shall provide daily reports indicating the Superintendent has walked through the project at the end of each work period, to satisfy himself there are no present conditions that may result in an accidental fire. Portable fire extinguishers shall be on site during this time. The General Contractor is responsible for inspecting and testing any temporary systems on a monthly basis.

ARTICLE 35 SURVEYS, RECORDS, and REPORTS

35.1 General: Working from lines and levels established by property survey, and as shown in relation to the Work, the General Contractor will establish and maintain bench marks and other dependable markers to set lines and levels for Work at each area of construction and elsewhere on site as needed to properly locate each element of the entire Project. The General Contractor shall calculate and measure from the bench marks and dependable markers required dimensions as shown (within recognized tolerances if not otherwise indicated) and shall not scale drawings to determine dimensions. General Contractor shall advise Sub-contractors performing Work of marked lines and levels provided for their use in layout of Work.

35.2 Survey Procedures: The General Contractor shall verify layout information shown on drawings, as required for his own Work. As Work proceeds, surveyor shall check every major element for line, level, and plumb (as applicable), and maintain an accurate Surveyor's log or Record Book of such checks available for General Contractor or Design Consultant's reference at reasonable times. Surveyor shall record deviations from required lines and levels and advise Design Consultant or General Contractor promptly upon detection of deviations exceeding indicated or recognized tolerances. The General Contractor shall record deviations which are accepted (not corrected) on Record Drawings.

ARTICLE 36 TOBACCO PRODUCTS PROHIBITED

36.1 For areas not located within Jefferson County, Kentucky, smoking is prohibited in all owned, operated, leased, or controlled University buildings and structures, parking structures, enclosed bridges and walkways, and vehicles. Smoking is also prohibited outside buildings and structures within 20 feet of entrances, exits, air intakes, and windows, unless further restricted by division policy.

36.2 Contractor employees violating this prohibition will be subject to dismissal from the Project.

ARTICLE 37 ALTERNATES - Not Applicable

ARTICLE 38 FIELD CONSTRUCTED MOCK UPS – Not Applicable

ARTICLE 39 PROJECT COORDINATION VIA COMPUTER

39.1 The General Contractor is required to have an active email account to facilitate coordination of the project during construction and warranty.

39.2 To facilitate project construction coordination between the Consultant, the General Contractor, and the University of Louisville as the Owner, UofL Project Management Division is hosting an Internet/ Web-based Project Management System (WPMS) to help improve project communication and collaboration. The Consultant shall participate in the use of the WPMS (Communication® or other system at the Owner's discretion) providing collaboration between Owner, the Consultant and selected contractors.

39.2.1 Owner shall provide the General Contractor with up to six user accounts and appropriate training for the web-based project management tool.

39.2.2 Utilization of, and training in the use of, the WPMS will be arranged for and supervised by Owner.

39.2.3 Participation of General Contractor is mandatory; others as determined by Owner.

39.2.4 All participants are required to have access to the internet and the Microsoft Internet Explorer browser (version 5.0 or higher). A broadband connection to the internet (e.g. Cable modem, ISDN, DSL) is recommended, but not required.

39.2.5 The WPMS shall be utilized for the following functions, as a minimum: Posting Project Files, AE Amendments, Architect's Supplemental Information (ASI's), Closeouts, Defective Work in Place, Meeting Minutes, Reports (Contractor Daily Reports, Field Reports, Commissioning Reports), Punch Lists, RFIs, Schedules, Submittals, Proposed Change Orders – Change Orders (PCO to CO's), Contracts, Pay Apps (pencil review), and Schedules. The Document Library (Bid set Plans, Specifications and Addenda will be uploaded by Lynn Imaging.

39.2.6 Site camera monitors may be included at Owner's discretion.

39.2.7 Utilization of the WPMS shall be implemented by the Owner's representative.

39.2.8 Use of the system will provide consistent, real-time information for decision making. Additionally, all project data entered into the system will be archived to facilitate project record keeping. It is anticipated that proper use of the WPMS will improve efficiency of communications and reduce project related paperwork and clerical workload.

ARTICLE 40 HOT WORK PERMITS

40.1 All work involving open flames or producing heat and/or sparks in occupied buildings on the University of Louisville campus will require the General Contractor to obtain approval to perform "Hot Work" on site. This includes, but is not limited to: Brazing, Cutting, Grinding, Soldering, Thawing Pipe, Torch Applied Roofing, and Cadwelding. A copy of the Hot Work Permit and the Hot Work Permit Procedure will be passed out at the Preconstruction Conference for the General Contractor's use.

ARTICLE 41 INSURANCE

41.1 Employers' Liability Insurance. The General Contractor shall acquire and maintain Employers' Liability insurance with at least \$500,000/\$500,000/\$500,000 limits of liability for all employees who will be working at the Project site.

41.2.1 Commercial General Liability Insurance. If the work involved requires the use of helicopters, a separate aviation liability policy with limits of liability of \$100,000,000 will be required. If cranes and rigging are involved, a separate inland marine policy with liability limits of \$100,000,000 will be required.

41.2.1.1 The limits of liability shall not be less than \$5,000,000 each occurrence combined single limits for bodily injury and property damage. If split limits are used, they shall not be less than \$2,000,000 for each person and each occurrence and \$1,000,000 for property damage.

41.2.2 Comprehensive Automobile Liability Insurance. Policy limits shall not be less than \$2,000,000 for combined single limits for bodily injury and property damage for each occurrence. As an alternative, split limits of not less than \$1,000,000 for bodily injury and \$500,000 for property damage for each occurrence shall be maintained.

41.2.3 Excess or Umbrella Liability Insurance. This policy shall have a minimum of \$5,000,000 combined single limits for bodily injury and property damage for each occurrence in excess of the applicable limits in the primary policies.

41.2.4 Workers' Compensation - Statutory Requirements (Kentucky)

ARTICLE 42 KEY ACCESS

42.1 If Construction Cores are NOT utilized, then one set of keys for access to the renovation project area will be provided to the General Contractor by the University's Project Manager. The General Contractor assumes responsibility for the safekeeping of the key(s) and its use. When leaving the renovation area all doors must be secured.

42.2 All keys must be returned to the University's Project Manager upon completion of project work as one of the requirements for Final Payment. Failure to return the keys may require re-keying of all doors in the work area up to and including the entire building if master keys are issued. The cost of re-keying of the door(s) accessed by the key(s) will be subtracted from the remaining contract dollars including contract retainage.

42.3 All lost or stolen keys must be reported immediately to the University's Project Manager.

ARTICLE 43 CEILING CLEARANCE – Not Applicable

ARTICLE 44 METAL ANCHORS

44.1 All anchoring devices utilized to secure materials to the building shall be metal. Plastic or plastic expansion components shall not be used. This shall include all fasteners for mechanical/electrical hangers.

END OF SECTION 20 1645

DIVISION 26 – ELECTRICAL

SECTION 26 0000 – GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1 GENERAL

- A. The General Conditions, Special Conditions, Supplemental Conditions, Instructions to Bidders, and other Contract Documents apply to this branch of the work as well as to the other branches.
- B. The Contractor shall familiarize himself with the work of all other trades, general type construction, and the relationship of his work to other sections. He shall examine all working drawings, specifications and conditions affecting his work. The Contractor shall visit the premises and thoroughly familiarize himself with all details of the work and working conditions, verify all dimensions in the field and advise the Engineer of any discrepancy before fabricating or performing any work.
- C. The work shall include complete testing of all equipment, conduit and wiring at the completion of the work and making any minor connection changes or adjustments necessary for the proper functioning of the system and equipment.
- D. Perform any necessary temporary work during construction.
- E. Work under this section shall conform to governing codes, ordinances and regulations of the City, County and State.
- F. The Contractor shall be responsible for any errors in fabrication, for the correct fitting, installation and erection of the various electrical systems.

1.2 SCOPE

- A. Furnish and install all wiring devices and equipment, etc., unless otherwise indicated, for the complete electrical systems. It is the intent that the entire electrical work and all electrical systems shall be complete in every respect and that all outlets, receptacles, fixtures, motors, equipment, devices, etc., shown, noted, or required shall be completely connected from source of power to final connection, ready for satisfactory operation.

1.3 ELECTRICAL MATERIALS

- A. It is the intent of these specifications that the conductive materials used in the manufacture of, but not limited to, the following types of equipment be of copper construction:
 - 1. Transformers (medium voltage and low voltage)
 - 2. Electrical Power Conductors and Cables (all voltages)
 - 3. Switchgear (all voltages)
 - 4. Switchboards
 - 5. Panelboards
 - 6. Unit Substations
 - 7. Motor Control Centers
 - 8. Transfer Switches

- 9. Enclosed Bus Assemblies
- 10. Power Distribution Units

1.4 CONCRETE FOUNDATION PADS

- A. The Contractor under this Division will provide all concrete curbs, bases and pads for all electrical equipment shown on the Drawings.
- B. The Contractor for this Division shall verify the sizes and locations of all supports, curbs, bases and pads prior to the pouring of same to be certain that the installed units will fit.
- C. The Contractor for this Division shall set anchor bolts in exact position prior to pouring of concrete. Sizes and locations of bolts shall be determined by the manufacturer's recommendations for the equipment served.
- D. All concrete pads shall be installed prior to setting equipment in place.

1.5 PROTECTION

- A. All work, equipment and materials shall be protected at all times. All conduit openings shall be closed with caps or plugs during construction. All equipment and accessories shall be tightly covered and protected against dirt, water or other injury during the period of construction.

1.6 AUTOMATIC TEMPERATURE AND ASSOCIATED SYSTEMS CONTROLS

- A. All wiring associated with the automatic temperature controls system and all associated conduit not specifically designated to be provided shall be included by others and specified under division of these specifications including motor starter interlock wiring.

1.7 EQUIPMENT FURNISHED BY OTHERS

- A. It shall be the responsibility of this Contractor to check voltage and current ratings of motors, relays, starters, switches, etc., of equipment furnished by others not connected under this section of the specifications. Nominal motor voltage ratings should be as follows:
 - 1. For connection to 480V system – NEMA 460 volts
 - 2. For connection to 208V system - NEMA 200 volts.
 - 3. For connection to 120V system - NEMA 115 volt.
- B. Motors not conforming to these ratings shall be called to the attention of the related subcontractor and the Owner/Engineer.

1.8 EQUIPMENT INSTALLATION INSTRUCTIONS

- A. Install electrical conduit, wiring and equipment in strict accordance with manufacturer's recommendations. Provide equipment accessories necessary for proper operation or recommended by the manufacturer, even if such accessories are not shown on the drawings or mentioned in the specifications.

1.9 INSTALLATION OF EQUIPMENT

- A. All appliances, materials and equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturers' instructions and recommendations. All electrical connections, etc., recommended by the manufacturer or required for proper operation shall be furnished and installed complete.

1.10 EQUIPMENT CONNECTIONS

- A. Make connections to equipment furnished by others whenever such equipment is shown on any part of the drawings or mentioned in any section of the specifications.
- B. Verify equipment locations and the sizes, number, locations, and types of connections to be made before installation of any such equipment.

1.11 OPENINGS

- A. The Contractor under this Division shall be responsible for the openings he may require in floors, walls or ceilings of any type construction whether or not shown on the Architectural and/or Structural Drawings.
- B. Openings that have not been shown on the Architectural and/or Structural Drawings shall be provided by the Contractor under this Division as directed by the Engineer.

1.12 FIRE BARRIER PENETRATION SEALS:

- A. Provide seals for any opening through any walls, floors, or ceilings used as passage for electrical components such as conduit, cabling, etc.
- B. General: Provide manufacturer's standard fire-stopping sealant, with accessory materials, having fire-resistance ratings as established by testing identical assemblies per ASTM E 814 by Underwriters' Laboratories, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction. Sealant shall provide protection equal or exceeding the fire resistance rating of fire rated walls, partitions, ceilings or floors. Use two-part or one part sealants as required to meet required fire resistance ratings.
- C. Foamed-In-Place Fire-Stopping Sealant: Two-part, foamed-in-place, silicone sealant formulated for use in a through-penetration fire-stop system for filling openings around cables, conduit, pipes and similar penetrations through walls and floors.
- D. One-Part Fire-Stopping Sealant: One part elastomeric sealant formulated for use in a through-penetration fire-stop system for sealing openings around cables, conduit, pipes and similar penetrations through walls and floors.
- E. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
- F. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Foamed-in-Place Fire-Stopping Sealant:
 - a. "Dow Corning Fire Stop Foam"; Dow Corning Corp.
 - b. "Pensil 85I"; General Electric Co.
 - 2. One-Part Fire-Stopping Sealant:
 - a. "Dow Corning Fire Stop Sealant"; Dow Corning Corp.

- b. "3M Fire Barrier Caulk CP-25"; Electrical Products Div./3M.
- c. "RTV 7403"; General Electric Co.
- d. "Fyre Putty"; Standard Oil Engineered Materials Co.

- G. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials to fill openings around mechanical and electrical services penetrating floors and walls to provide fire-stops with fire resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

1.13 SINGULAR NUMBER

- A. In all cases where a device or piece of equipment is referred to in the singular number (such as a light fixture, etc.), it is intended that such reference shall apply to as many such items as are required to complete the installation.

1.14 CONNECTION TO EXISTING ELECTRICAL SYSTEMS

- A. The Contractor under this Division shall make all necessary electrical connections to all undisturbed existing electrical systems, as shown on the Drawings and/or required for their proper operation with the new system.

1.15 CATALOG DATA FOR THE OWNER

- A. The Contractor under this Division shall prepare four (2) loose-leaf, plastic bound brochures and (1) digital copy entitled "University of Louisville Health Science Campus Buildings 55a and 55b – Unit Substation Replacement -- Electrical Operation and Maintenance Data."
- B. Each brochure shall contain the following information:
 - 1. Name and address of Consulting Engineer, Contractor and index of equipment, including vendor (name and address).
 - 2. Complete brochures, descriptive data, etc., on each piece of equipment, including all reviewed and stamped shop drawings.
 - 3. Complete maintenance and operating instructions and parts list, prepared by the manufacturer, on each major piece of equipment.
 - 4. All wiring diagrams for equipment and systems and control schematics.
- C. Brochures shall be provided with tabbed index and complete Table of Contents. The page after index of each tab shall contain a summary schedule listing checks and maintenance functions required for each piece of equipment. The schedule shall be divided into daily, weekly, monthly and annual time frames as required.
- D. Brochures shall be submitted to the Owner/Engineer prior to final inspection of the building.

1.16 SPECIAL NOTE

- A. All openings in electrical equipment, enclosures, cabinets, outlet and junction boxes shall be by means of standard knockouts or shall be sawed or drilled. The use of a cutting torch is prohibited.

1.17 EQUIPMENT IDENTIFICATION

- A. The Contractor for this Division shall furnish and install on all electrical equipment such as switches, starters, panelboards, etc., a nameplate giving its name and function.
- B. Nameplates shall be engraved bakelite (white letters on black background) and shall be equal to Seton Nameplate, C. H. Hanson or Identifications.

1.18 MOTOR PROTECTION INFORMATION

- A. The Contractor for this Division shall provide the following information for each motor installed on this project, regardless of the supplying Contractor:
 - 1. Motor full load current
 - 2. Motor starter heater size - where applicable
 - 3. Fuse size
- B. This information shall be provided in tabulation form before final payment will be made to the Contractor.

1.19 EQUIVALENT MATERIAL AND EQUIPMENT

- A. The material and equipment described herein have been specified according to particular trade names or makes; however, the Contractor may offer substitute material and equipment in lieu of that specified, provided such material and equipment meet all the requirements of those specified and are approved by the Owner/Engineer. The manufacturer's warranty covering each item of substituted material or equipment shall be equal to the warranty covering the material or equipment specified.
- B. Where equipment is approved which requires different arrangement of connections from those shown, it shall be the responsibility of the Contractor to install the equipment to operate properly and in harmony with the intent of the Drawings and Specifications, and to make all changes in the work required by the different arrangement of connections.

1.20 PERMITS, CODES AND APPROVALS

- A. Permits
 - 1. All permits necessary for the complete Electrical systems shall be obtained by the Contractor for Division 26 from the authorities governing such work. The cost of all permits shall be borne by this Contractor.
- B. Codes and Rules and Regulations
 - 1. The minimum standard for all electrical work shall be the latest revision of the National Electrical Code. Whenever and wherever state and/or local laws and/or regulations require a higher standard than the current National Electrical Code, then these laws and/or regulations shall be followed.
- C. Approvals
 - 1. All work must be approved by the Engineer and the Owner before final payment will be made.

1.21 INSPECTIONS

- A. Electrical inspections will be performed throughout the course of construction by an electrical inspector from the State Fire Marshal's office. Upon project completion, and when wiring, equipment and fixtures have been installed, inspected and found to be in compliance with the National Electrical Code, the inspector will issue a certificate of compliance to the Owner.
- B. The Contractor under this Division shall furnish electrical inspection by the inspection agency having jurisdiction. The Electrical Inspector shall be notified in writing immediately upon the start of the work and a copy of the notice shall be sent to the Owner/Engineer. All costs incidental to the electrical inspection shall be borne by the Contractor for Division 26.
- C. The inspection shall be scheduled for rough as well as finished work. The rough inspection shall be divided into as many inspections as may become necessary to cover all roughing-in. A punch list inspection shall be scheduled with a representative of the Owner/Engineer present. The punch list inspection shall be made with panelboard and junction box covers removed.
- D. Before final acceptance, the Contractor for Division 26 shall furnish a Certificate of Final Approval by the Electrical Inspector to the Engineer and the Owner.

1.22 UL LISTINGS

- A. Materials and appliances for the type for which there are Underwriters' Laboratories standard requirements listings and labels, shall have listing of Underwriters' Laboratories and shall be so labeled, or shall conform to their requirements, in which case certified statements to that effect shall be furnished by the manufacturer with a copy of an examination report by a recognized testing laboratory acceptable to the Engineer.

1.23 WORKMANSHIP

- A. Competent workmen shall be employed on all phases of the work. Poor workmanship will be rejected and will constitute cause for removal of the individual performing the work.

1.24 COOPERATION WITH OTHER CONTRACTORS

- A. Each Contractor shall demand and examine all Drawings and Specifications pertaining to the construction before installing the work described and shown under these Drawings and Specifications. Each Contractor shall cooperate with all other Contractors in locating piping, conduit, openings, chases and equipment in order to avoid conflict with any other Contractor's work. All work installed above a lay-in ceiling must be coordinated and installed so there is a minimum of 4 inches between the top of the ceiling grid and the bottom of the installation.
- B. If any discrepancies occur between the accompanying Drawings and these Specifications and Drawings and Specifications covering other Contracts, each Contractor 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 piping, ductwork, conduit and equipment not installed in accordance with the above instructions, and which interferes with work and equipment of other Contractors.

1.25 MAINTAINING EXISTING FACILITIES

- A. The existing services to and within the building shall be maintained during the construction without interruption, except for short periods of time that may be required to make changeover connections. The Owner and Engineer shall be notified in advance and an agreement reached as to when the connections are to be made and the length of time the particular facility will be out of service.
- B. All temporary connections that may be necessary to continue these services shall be properly made and maintained in a safe and substantial manner until the permanent facilities are activated. Upon completion, remove all temporary work, and completely restore all areas that may be affected.
- C. At any time the existing building facilities are interrupted, the Contractor shall work continuously until the permanent services are restored. The Contractor shall pay for all premium time necessary to comply with these requirements.

1.26 EXTERIOR LIGHTING

- A. This contractor shall provide temporary lighting, if required, to maintain adequate illumination for safety and security for all immediate adjacent areas to the construction site whose illumination is affected by the construction activities. Illumination requirements shall be in accordance with the recommendations as set forth by IESNA standards.
- B. Installation and operation of the temporary lighting is to be reviewed for approval by the Owner and Engineer.

1.27 GUARANTY CERTIFICATES

- A. Certificates of guaranty accompanying those items of mechanical and electrical equipment on which manufacturer's guarantees have been specified, or are normally provided, shall be completely executed by the Contractor and delivered to the Owner before completion of the work.

1.28 REMOVAL OF EXISTING EQUIPMENT AND SALVAGE

- A. The Contractor for this Division shall remove all exposed electrical equipment and materials that are not to be reused in the new electrical arrangement.
- B. All other equipment and materials shall become the property of the Contractor and shall be removed from the site.

1.29 ALTERNATES

- A. The Contractor under this Division shall refer to Division 1 of the Specifications for a complete description of the Alternates. Note that all alternates are ADDITIVE (DEDUCTIVE). The work detailed on the Drawings and specified are for the complete project, including all Alternates.

1.30 CLEANING

- A. After the Owner/Engineer has completed examination, the Contractor shall remove all stickers, tags, etc., and shall thoroughly clean all equipment, fixtures and materials installed under his section of the work.

- B. Surplus material, rubbish and equipment resulting from the work shall be removed from the building and premises by the respective Contractors upon completion of the work in accordance with the General Conditions.

1.31 PAINTING

- A. All exposed conduit and equipment installed under this Division, where required, shall be thoroughly cleaned and readied for painting.
- B. Painting in all areas of the existing building which have been cut and patched under this Division shall be painted to match exactly the existing adjacent surfaces. Where a match cannot be made, the entire surface shall be repainted. All exposed electrical work in these areas shall also be painted to match adjacent surfaces.

1.32 WORKMANSHIP

- A. Work shall be performed by mechanics skilled in their respective trades and shall present appearance typical of best trade practice. Work not installed in this manner shall be repaired, removed or replaced, or otherwise remedied as directed by the Owner/Engineer.

1.33 SUPERVISION

- A. The Contractor shall personally supervise the work or have a competent superintendent, satisfactory to the Engineer and Owner on the work at all times during progress with full authority to act.
- B. The Contractor shall lay out his work and be responsible for any 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. Work at the site of the project shall be observed by the Engineer or his representative.
- C. Final Inspection: At the time of final inspection of the work performed under this Contract, systems shall be complete in every respect and in perfect operating condition. Surplus materials of every character resulting from work of this section shall have been removed. Sanitary sewers shall be free from sand, silt or other obstructions. Any defect discovered in the utilities subsequent to this inspection shall have been corrected.

1.34 INTERPRETATIONS

- A. Wherever in these Specifications, the term "General Contractor" is used, it shall be understood to mean the Contractor engaged in the general construction portion of the work. Similarly, wherever the "Heating and Air Conditioning Contractor," "Plumbing Contractor," "Sprinkler Contractor," or "Contractor for Division 26" is mentioned as such, it shall be understood to refer to the Contractor engaged in that particular branch of the work.
 - 1. It shall also be clearly understood that all Contractors for all branches of the work shall cooperate with each other in the coordination of the construction.
 - 2. It shall also be clearly understood that the entire construction is one responsibility and all Contractors for all branches of the work shall cooperate with each other in the coordination of the construction.

1.35 WORKING DRAWINGS

- A. Scale of drawings is approximate. Do not scale the drawings to determine locations of electrical work. Exact locations, dimensions and elevations shall be governed by field conditions. Make field measurements of building before fabricating or installing equipment or materials.
- B. Drawings are based on physical dimensions of one or more manufacturer's equipment. Other approved equipment shall be of such dimensions that it can be readily installed in available space, leaving ample clearance for proper maintenance.
- C. Intent of drawings is to show systems and sizes. Drawings do not necessarily show all required offsets. Work shall be installed to conform with space limitations. Offsets, transitions, fittings, etc., shall be provided as part of the Contract where required to attain this objective.

1.36 ELECTRICAL DRAWINGS AND SPECIFICATIONS

- A. The Drawings and Specifications are intended to cover all work enumerated under the respective headings. The Drawings are diagrammatic only. The Contractor shall not take advantage of conflict or error between the Drawings and Specifications but shall request a clarification of such before making his proposal.

1.37 ARCHITECTURAL DRAWINGS AND SPECIFICATIONS

- A. The Contractor shall refer to the Drawings and Specifications for the general construction of the building, for floor and ceiling heights, for location of walls, partitions, beams, etc., and shall be guided accordingly for the setting of all sleeves, inserts and equipment.
- B. Under no circumstances shall a Contractor scale the Drawings for the location of equipment and work.

1.38 DISCREPANCIES

- A. If any discrepancies occur between the accompanying Drawings and these Specifications and Drawings and Specifications covering other Contracts, report such discrepancies to the Owner/Engineer far enough in advance so that a workable solution can be presented. No extra payment will be allowed for relocation of piping, ductwork, conduit and equipment not installed in accordance with the above instructions, and which interferes with work and equipment of other Contractors.

1.39 RESTORATION OF SURFACES

- A. The Contractor shall restore to their original conditions all paving, curbing, sidewalks, surfaces, drainage ditches, and structures, fences, shrubs, and other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match material employed in the original construction of the item to be replaced.

1.40 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

1.41 SHOP DRAWINGS

- A. Equipment and material shop drawings, catalog sheets and descriptive data shall be submitted, each with a cover sheet first listing the project name, the Contractors, Engineer, and date of submittal. Next the section of the Specifications shall be listed stating the section for which the equipment is being proposed. Next, outline equipment showing compliances to the specification requirements, such as capacities, special accessories, options, model, sizes, etc. Reverse side of cover sheet shall be left for Contractors' stamps showing review and space for Engineers' review stamp. Catalog sheets shall be marked showing equipment proposed.
- B. Materials submitted without cover sheet or Contractor review stamp and without required information will be returned to the Contractor.

1.42 STRUCTURAL RESPONSIBILITY

- A. The 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. No structural member shall be cut or otherwise weakened in any manner without the written consent of the Engineer.
- B. 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 Owner or Engineer, without cost to either the Owner or the Engineer.

1.43 HAZARDOUS MATERIALS

- A. Refer to Special Conditions, Section 00801.

1.44 ASBESTOS

- A. If during the course of his work the Contractor observes the existence of asbestos, or asbestos-bearing materials, the Contractor shall immediately terminate further work on the project and notify the Owner of the condition. The Owner will, after consultation with the Engineer, determine a further course of action.

1.45 OWNER INSTRUCTION

- A. Conduct a full-day walk-through instruction seminar for the Owner's personnel to be involved in the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, efficiency and similar features of the systems.
- B. All training shall be video recorded for future use by the Owner in training new personnel.

1.46 OWNER OCCUPANCY

- A. Full Owner Occupancy: The Owner will occupy the site and building surrounding construction area during the entire construction period. Cooperate with the Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work to minimize interference with the Owner's operations. Perform portions of work on premium time if required to do so by the Owner.

1.47 PROVIDING AIRTIGHT SPACES

- A. In rooms where room walls extend above ceiling to the floor or roof above, caulk around all new and existing penetrations through walls, ceilings, floors and/or roofs to make completely airtight rooms. Seal penetrations both above and below suspended ceilings. Seal any openings left by removal of any existing or new work.
- B. Patch around rough openings of penetrations to form a tight fit before caulking.

1.48 LINTELS:

- A. General: Provide lintels for penetration of electrical systems through masonry walls if not provided elsewhere in these specifications. Lintels shall be type and size required to span the required openings.
- B. Lintels will not be required for openings 16 inches length or less.

1.49 ELECTRICAL WORK IN EXISTING (RENOVATED) AREAS

- A. In existing areas where new work is shown, remove all existing exposed conduits, wiremold, surface and flush outlet boxes, wiring devices, fixtures, panels, etc., not required for new arrangement.
- B. Maintain and restore, if interrupted by removals or in path of new construction, all circuits, conduits and feeders passing through and serving undisturbed areas (shown or not shown).
- C. Install all new work as indicated. Flush outlet boxes may be reused if at proper height, location and in good condition. Existing concealed conduits may be reused if in good condition, circuitry shown on plans shall govern. All other materials removed shall be removed from the job site or turned over to the Owner.
- D. Where any existing outlet (electric, telephone, nurse call, TV, etc.) is noted or required to be removed, the Contractor under this Division shall connect conduit, pull in new conductors and reconnect as required for feed-thru of circuits to ensure all circuits downstream from removed outlets will remain operational.
- E. Before start of work, the Contractor shall check all existing devices, light fixtures and equipment that is noted or required to be reused, to satisfy himself that they are operating properly. Should any of the items not be operating, the Contractor shall report same to the Engineer, and await his directions. Contractors not complying with the above will be responsible for providing operational items as his expense.
- F. Contractor shall make a complete survey of the existing building before bidding the project. Any conflicts between the plans and/or notes and existing conditions must be brought to the attention of the Owner/Engineer before bidding. If no questions and/or conflicts are brought to the attention of the Owner/Engineer, it will be assumed that the Contractor has completed the survey.

PART 2 - PRODUCTS

- 2.1 Not Applicable

PART 3 - EXECUTION

3.1 Not Applicable

END OF SECTION 26 0000

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate sleeve selection and application with selection and application of firestopping.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Stainless steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Stainless steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used.
- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level and seal watertight.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials
- J. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- K. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

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

3.4 FIRESTOPPING

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

END OF SECTION 26 0500

SECTION 26 0513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

- A. Jacket: A continuous nonmetallic outer covering for conductors or cables.
- B. NETA ATS: Acceptance Testing Specification.
- C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer. Installer must be AVO certified to install, terminate, and test medium voltage cables. Refer to U of L Standards for specific requirements.
- B. Material Certificates: For each type of cable and accessory.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than 14 days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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 IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. General Cable; General Cable Corporation.
 - 2. Okonite Company (The).
 - 3. Southwire Company.
- B. Cable Type: Type MV 105.
- C. Conductor Insulation: Ethylene-propylene rubber.
 - 1. Voltage Rating: 15 kV.
 - 2. Insulation Thickness: 133 percent insulation level.
- D. Conductor: Copper.
- E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.
- F. Conductor Stranding: Compact round, concentric lay, Class B.
- G. Strand Filling: Conductor interstices are filled with impermeable compound.
- H. Shielding: Copper tape, helically applied over semiconducting insulation shield with 25% overlap (minimum).
- I. Cable Jacket: Chlorosulfonated polyethylene.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. 3M.
 - 2. Cooper Power Systems, an Eaton business.
 - 3. Raychem; a brand of nVent.
 - 4. TE Connectivity Ltd.
- B. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.4 SOLID TERMINATIONS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. Cooper Power Systems, an Eaton business.
 3. Raychem; a brand of nVent.
 4. TE Connectivity Ltd.
- B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer non-tracking tubes; multiple, molded, non-tracking skirt modules; and compression-type connector.
 2. Class 2 Terminations, Indoors: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
 3. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. Cooper Power Systems, an Eaton business.
 3. Raychem; a brand of nVent.
 4. TE Connectivity Ltd.
- C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- E. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- F. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

- A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. Cooper Power Systems, an Eaton business.
 3. Raychem; a brand of nVent.
 4. TE Connectivity Ltd.
- C. Standard: Comply with IEEE 404.
- D. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.

2.7 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. Raychem; a brand of nVent.
 3. TE Connectivity Ltd.
- C. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.
- D. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

2.8 ARC-PROOFING MATERIALS

- A. Description: Fire retardant, providing arc flash protection.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. Raychem; a brand of nVent.
 3. TE Connectivity Ltd.
- C. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.

2.9 FAULT INDICATORS

- A. Indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
- B. On each phase of new cables one existing switch, a fault indicator shall be required. The fault indicator shall be rated at 1200 amps with inrush restraint, current reset and snap action clamp for cable with O.D. of 1.6". The fault indicator shall be an SEL model number 1CRD1200SIR. The fault indicator shall have one combination display for each set of cables and be installed and positioned to be read easily from the switch operator side of the vault.
- C. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.
 - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 - 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
 - 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

- F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag. Provide at least 4 feet of slack within the manhole.
- G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- H. Install cable splices at pull points and elsewhere as indicated; use standard kits.
- I. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.
- J. Install separable insulated-connector components as follows:
 - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
 - 3. Standoff Insulator: At each terminal junction, with one on each terminal.
- K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
 - 1. Clean cable sheath.
 - 2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
 - 3. Smooth surface contours with electrical insulation putty.
 - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 - 5. Band arc-proofing tape with two layers of 1-inch- (25-mm-) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.
- L. Install fault indicators on each phase where the cables terminate onto medium voltage switches within manholes.
- M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- N. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- O. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage. See U of L Standards for additional information on testing of medium voltage cables.
- C. All proper testing hardware and equipment shall be onsite ready for use prior to commencement of the testing. This includes
 1. Properly calibrated test equipment for the range of testing voltages to be used.
 2. Proper insulating plugs to insulate exposed ends of cable where possible.
 3. Proper connecting hardware to facilitate connection of testing leads and equipment.
 4. Where possible, connect test unit to a stable power source so as not to influence test results.
- D. All tests must be recorded on a form sheet signed by the person performing the test and dated. The Engineer or a designated representative of the Owner must be present during the testing. Notify the Engineer and Owner within seven days of the anticipated date of testing.
- E. An electronic copy shall be submitted to the Engineer and Owner via email or mobile phone text immediately following the test.
- F. Medium-voltage cables will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 26 0513

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

- A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Alpha Wire.
 - 2. Belden Inc.
 - 3. Encore Wire Corporation.
 - 4. General Cable Technologies Corporation.
 - 5. Southwire Incorporated.
- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2
- D. Minimum conductor size: #12 AWG

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Gardner Bender.
 - 3. Hubbell Power Systems, Inc.
 - 4. Ideal Industries, Inc.
 - 5. Ilsco; a branch of Bardes Corporation.
 - 6. NSi Industries LLC.
 - 7. O-Z/Gedney; a brand of the EGS Electrical Group.
 - 8. 3M; Electrical Markets Division.
 - 9. Tyco Electronics.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

- 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 NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

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

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.3 CONNECTIONS

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

3.4 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "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.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260500 "Common Work Results for Electrical."

END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Ground bonding common with lightning protection system.
 - 2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Ground rods.
 - 2. Grounding arrangements and connections for separately derived systems.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. Include the following:
 - a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article.
 - b. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NFPA 70B.
 - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ERICO International Corporation.
 - 2. Harger Lightning & Grounding.
 - 3. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 4. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Conduit Hubs: Mechanical type, terminal with threaded hub.
- G. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- H. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- I. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- K. Straps: Solid copper, copper lugs. Rated for 600 A.
- L. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- M. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless-steel 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.

2.5 GROUNDING ELECTRODES

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

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors.

3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 EQUIPMENT GROUNDING

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

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. 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.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 1. Material: Galvanized steel.
 - 2. Channel Width: 1-5/8 inches (41.25 mm).
 - 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 4. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

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

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for conduit as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, RMCs may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To New Concrete: Bolt to concrete inserts.
 2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 3. To Existing Concrete: Expansion anchor fasteners.
 4. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.

- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete.
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Boxes, enclosures, and cabinets.
- B. Related Requirements:

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Allied Tube & Conduit.
 - 2. O-Z/Gedney.
 - 3. Republic Conduit.
 - 4. Robroy Industries.
 - 5. Thomas & Betts Corporation.
 - 6. Western Tube and Conduit Corporation.
 - 7. Wheatland Tube Company.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- E. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.

2. Fittings for EMT:

- a. Material: Steel.
- b. Type: Compression type for conduit sizes 2-1/2" and smaller; set-screw or compression type for conduit sizes larger than 2-1/2".

- F. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman.
7. Hubbell Incorporated.
8. Milbank Manufacturing Co.
9. Mono-Systems, Inc.
10. O-Z/Gedney.
11. RACO; Hubbell.
12. Robroy Industries.
13. Spring City Electrical Manufacturing Company.
14. Stahlin Non-Metallic Enclosures.
15. Thomas & Betts Corporation.
16. Wiremold / Legrand.

- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X.

- B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. All locations:
 - a. EMT where not subject to physical damage
 - b. GRC where physical damage is possible
 2. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 3. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- 3.2 INSTALLATION
- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
 - B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
 - C. Complete raceway installation before starting conductor installation.
 - D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
 - E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
 - F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
 - G. Support conduit within 12 inches (300 mm) of enclosures to which attached.
 - H. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
 - I. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
 - J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
 - K. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal

bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

- L. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- M. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- N. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- O. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- P. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 18 inches (1830 mm) of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC.
- Q. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260500 "Common Work Results for Electrical."

3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER - HIGH VOLTAGE WIRING."
- B. Warning labels and signs 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 36 INCHES (915 MM)."

2.3 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

2.4 LABELS & SIGNS

- A. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Engraved legend.
 - 2. Thickness:
 - a. For signs up to 20 sq. inches (129 sq. cm), minimum 1/16-inch- (1.6-mm-).
 - b. For signs larger than 20 sq. inches (129 sq. cm), 1/8 inch (3.2 mm) thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Fasteners for Labels and Signs: Stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- H. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- I. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds 16 inches (400 mm) overall.

3.3 IDENTIFICATION SCHEDULE

- A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.
 - a. Color shall be factory applied.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.

- B. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- C. 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 operation and maintenance manual.
- D. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- E. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.
 - 1. Comply with NFPA 70E and ANSI Z535.4.
 - 2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
- F. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- G. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and 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 unless equipment is provided with its own identification.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless labels are provided with self-adhesive means of attachment, fasten them 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 in the form of a engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Switchgear.
 - d. Switchboards.

- e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- f. Substations.
- g. Enclosed switches.
- h. Enclosed circuit breakers.
- i. Enclosed controllers.
- j. Variable-speed controllers.
- k. Push-button stations.

3. Label Nomenclature and Format

- a. The components will be labeled using the following format:

ID: Room No./Equipment name-Specific device number
 Fed from: Room No./Equipment name-Specific device number

- b. Each field has a specified number of characters and is defined as follows:
 - 1) Room (up to 5 capitalized characters) => the room in which the component is located; if component is in a corridor use "CORR".
 - 2) Equipment Name (up to 8 capitalized characters) => the name of the particular type of equipment from the PPDMC equipment naming convention list shown below.
 - 3) Specific Number (up to 3 characters) => the number of that particular device from the drawing or the next sequential number in that equipment type.

Equipment Description	Equipment Name
Critical Branch Automatic Transfer Switch	C/ATS-x
Critical Branch Distribution Panel	C/DP-x
Critical Branch Motor Control Ctr	C/MCC-x
Critical Branch Panel	C/P-x
Critical Branch Switchboard	C/SWBD-x
Critical Branch Switchgear	C/SWGR-x
Emergency Automatic Transfer Switch	E/ATS-x
Emergency Distribution Panel	E/DP-x
Emergency Generator	EG-x
Emergency Motor Control Ctr	E/MCC-x
Emergency Panel	E/P-x
Emergency Switchboard	E/SWBD-x
Emergency Switchgear	E/SWGR-x
Emergency Transformer	E/T-x
Life Safety Automatic Transfer Switch	LS/ATS-x
Life Safety Distribution Panel	LS/DP-x
Life Safety Panel	LS/P-x
Life Safety Switchboard	LS/SWBD-x
Life Safety Switchgear	LS/SWGR-x
Life Safety Transformer	LS/T-x

Normal Power Automatic Transfer Switch	N/ATS-x
Normal Power Distribution Panel	N/DP-x
Normal Power Motor Control Ctr	N/MCC-x
Normal Power Panel	N/P-x
Normal Power Switchboard	N/SWBD-x
Normal Power Switchgear	N/SWGR-x
Normal Power Transformer	N/T-x

c. Examples:

- A typical normal power distribution panel on the second floor of the main hospital in room H-201 might be labeled “H201/N/DP-1”.
- A motor control center in the penthouse of the Combs building might be labeled “401/N/MCC-1”.
- A chilled water pump in H-46 might be labeled as “H46/CHW/PMP-1” for the load designation and “H46/N/P-3” for the source designation.

- d. NOTE: The component identification number, or sequence number, is just a simple numbering of similar equipment on the same floor numbered from left to right as seen on the electrical distribution riser diagram provided by the architects. Therefore, it is important to note the building and floor when referring to a component to determine its location. If the components to be labeled are existing equipment or new equipment in an existing building, the component sequence number should be obtained from the appropriate electrical systems supervisor. If the equipment is being installed as part of a new building construction project, then the contractor may determine the sequence numbers.

END OF SECTION 26 0553

SECTION 26 0573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
- B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- G. SCCR: Short-circuit current rating.
- H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- I. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. For computer software program to be used for studies.
 - 2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

- a. Short-circuit study input data, including completed computer program input data sheets.
- b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - 1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - 2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
2. The following are from the Short-Circuit Study Report:
 - a. Final one-line diagram.
 - b. Final Short-Circuit Study Report.
 - c. Short-circuit study data files.
 - d. Power system data.
3. The final Short-Circuit Study Report shall be submitted in a format that is fully compatible with SKM Systems Analysis software.

1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
 1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. EDSA Micro Corporation.
 - 2. Power Analytics, Corporation.
 - 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 399 and IEEE 551.
 - 1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Switchgear and panelboard designations and ratings. Only panelboards in the first level from the main switchgear need to be included.
 - 5. Derating factors and environmental conditions.
 - 6. Any revisions to electrical equipment required by the study.

- D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- E. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
 5. 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.
- F. Short-Circuit Study Input Data:
1. One-line diagram of system being studied.
 2. Power sources available.
 3. Manufacturer, model, and interrupting rating of protective devices.
 4. Conductors.
 5. Transformer data.
- G. Short-Circuit Study Output Reports:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary 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. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
 3. 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.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
 - 1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Engineer's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
 - 3. For equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.
- B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 - 1. Product Data for Project's overcurrent protective devices 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. Obtain electrical power utility impedance at the service.
 - 3. Power sources and ties.
 - 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 - 5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 - 6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
 - 7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 - 8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 - 9. Motor horsepower and NEMA MG 1 code letter designation.
 - 10. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
 - 11. Derating factors.

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.

- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than or equal to 225 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 26 0573.13

SECTION 26 0573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

- 1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
- B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- E. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- G. SCCR: Short-circuit current rating.
- H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- I. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

- A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power System Analysis Software Developer.
2. For Power Systems Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

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

1. The following are from the Coordination Study Report:
 - a. Final one-line diagram.
 - b. Final protective device coordination study.
 - c. Coordination study data files.
 - d. List of all protective device settings.
 - e. Time-current coordination curves.
 - f. Power system data.
2. The final Coordination Study Report shall be submitted in a format that is fully compatible with SKM Systems Analysis software.

1.7 QUALITY ASSURANCE

- A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.

- D. Power System Analysis Software Qualifications:
1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Field Adjusting Agency Qualifications:
1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
 2. A member company of NETA.
 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. EDSA Micro Corporation.
 2. Power Analytics, Corporation.
 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. 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.
1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, 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.
6. Any revisions to electrical equipment required by the study.
7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. 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, and 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.

E. 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. Generator short-circuit decrement curve and generator damage point.
 - j. The largest feeder circuit breaker in each motor-control center and panelboard.
- 5. Maintain selectivity for tripping currents caused by overloads.
 - 6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
 - 7. Provide adequate time margins between device characteristics such that selective operation is achieved.
 - 8. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the overcurrent protective device study.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Engineer's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
 - 3. For equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.
- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 - 1. Product Data for overcurrent protective devices specified in other 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. Electrical power utility impedance at the service.
 - 3. Power sources and ties.

4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
17. Data sheets to supplement electrical distribution system one-line 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. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
 - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.

- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than or equal to 225 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. 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.
- H. Motor Protection:
 - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations 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.
- J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.
- K. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.
- L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- M. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.
 - 4. Include in the report identification of any protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
 - 1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
 - 2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
 - 3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.6 DEMONSTRATION

- A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:
 - 1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
 - 2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
 - 3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573.16

SECTION 26 0573.19 - ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes a 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.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- G. SCCR: Short-circuit current rating.
- H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- I. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form:
 - 1. Arc-flash study input data, including completed computer program input data sheets.

2. Arc-flash study report; signed, dated, and sealed by Power Systems Analysis Specialist.
3. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Provide maintenance procedures in equipment manuals according to requirements in NFPA 70E.
2. The final Arc Flash Report shall be submitted in a format that is fully compatible with SKM Systems Analysis software.

1.7 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

G. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. EDSA Micro Corporation.
 2. Power Analytics, Corporation.
 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram, showing the following:
 1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- G. Arc-Flash Study Output Reports:
 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
 - 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.

H. 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. Restricted approach boundary.
- 6. Limited approach boundary.
- 7. Working distance.
- 8. Incident energy.
- 9. Hazard risk category.
- 10. Recommendations for arc-flash energy reduction.

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

2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
- B. 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. Location designation.
 - 2. Nominal voltage.
 - 3. Protection boundaries.
 - a. Arc-flash boundary.
 - b. Restricted approach boundary.
 - c. Limited approach boundary.
 - 4. Arc flash PPE category.
 - 5. Required minimum arc rating of PPE in Cal/cm squared.
 - 6. Available incident energy.
 - 7. Working distance.
 - 8. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
 - 2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
 - 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
 - 3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.
 - 4. Calculate arc-flash energy with the utility contribution at a minimum and assume no motor contribution.
- D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers equal to or less than 225 kVA.
- F. Calculate the limited, restricted, and prohibited approach boundaries for each location.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
 - 1. Fault contribution from induction motors shall not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the arc-flash hazard analysis.
1. Verify completeness of data supplied on one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Engineer's attention.
 2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.
 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
1. Product Data for overcurrent protective devices specified in other 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. Obtain electrical power utility impedance or available short circuit current at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus (three phase and line to ground).
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 12. Motor horsepower and NEMA MG 1 code letter designation.
 13. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
 14. Medium-voltage conductor sizes, lengths, conductor material, conductor construction and metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).

3.4 LABELING

- A. Apply one arc-flash label on the front cover of each section of the equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.
- B. Each piece of equipment listed below shall have an arc-flash label applied to it:
 - 1. Switchgear.
 - 2. Medium-voltage switch.
 - 3. Medium voltage transformers
 - 4. Low voltage transformers. Exclude transformers with high voltage side 240 V or less and less than or equal to 225 kVA.
 - 5. Panelboard and safety switch over 250 V.
 - 6. Applicable panelboard and safety switch under 250 V.
 - 7. Control panel.
- C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.
 - 1. Indicate arc-flash energy.
 - 2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

- A. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

3.6 DEMONSTRATION

- A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels.

END OF SECTION 26 0573.19

SECTION 26 1116.11 - SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary switchgear section, with the following features:
 - 1. Indoor enclosure.
 - 2. Medium-voltage, metal-enclosed switchgear section.
 - 3. Dry-type transformer.
- B. Related Requirements:
 - 1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.3 DEFINITIONS

- A. BIL: Basic insulation level.
- B. MCC: Motor-control center.
- C. MVA: Megavolt ampere.
- D. NETA ATS: Acceptance testing specification.
- E. NiCd: Nickel cadmium.
- F. PCB: Polychlorinated biphenyl.
- G. RTD: Resistance temperature device.
- H. SCR: Silicon-controlled rectifier.
- I. SPD: Surge protective device.
- J. VRLA: Valve-regulated lead acid.

1.4 ACTION SUBMITTALS

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

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 1. Wiring Diagrams: Power, signal, and control wiring.
 2. Dimensioned plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
 3. One-line diagram.
 4. List of materials.
 5. Nameplate legends.
 6. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
 7. Short-time and short-circuit current ratings of secondary unit substations and components.
 8. Ratings of individual protective devices.
 9. Mimic-bus diagram.
- C. Time-Current Characteristic Curves: For overcurrent protective devices.
- D. Primary Fuses: Submit recommendations and size calculations.
 1. Utility company's metering provisions with indication of approval by utility company.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings for Indoor Installations:
 1. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
 2. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
 3. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
 4. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways.
 5. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.
- B. Qualification Data: For testing agency.
- C. Product Certificates: For secondary unit substations, signed by product manufacturer.
- D. Factory test reports.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:
 - a. Primary disconnect fuses.
 - b. Potential transformer fuses.
 - c. Control power fuses.
 - 2. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
 - 3. Primary Switch Contact Lubricant: One container(s).

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
- B. Coordinate delivery of secondary unit substations to allow movement into designated space.
- C. Store secondary unit substation components protected from weather and so condensation does not form on or in units. Provide temporary heating according to manufacturer's written instructions.
- D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.10 FIELD CONDITIONS

- A. **The new unit substation must fit within the footprint of the existing switchgear being removed. Expansion/extension of the existing concrete pad will not be allowed. The new equipment must also encompass the existing conduits coming up from the floor slab.**
- B. Service Conditions: The unit substation shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.121, except for the following:
 - 1. Exposure to significant solar radiation.
 - 2. Altitudes above 3300 ft. (1000 m).
 - 3. Exposure to fumes, vapors, or dust.
 - 4. Exposure to explosive environments.
 - 5. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
 - 6. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
 - 7. Exposure to excessively high or low temperatures.
 - 8. Unusual transportation or storage conditions.

9. Unusual grounding resistance conditions.
10. Unusual space limitations.

1.11 WARRANTY

- A. **Manufacturer's Special Warranty:** Manufacturer agrees to repair or replace components of the dc system battery equipment that fail(s) in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
 1. **Warranty Period:** Include the following warranty periods, from date of Substantial Completion:

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Eaton.
 2. General Electric Company.
 3. Siemens Industry, Inc., Energy Management Division.
 4. Square D; by Schneider Electric.

2.2 SYSTEM DESCRIPTION

- A. **Description:** Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers and metering components.
 1. **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.
 2. **Comply with IEEE C2.**
 3. **Comply with IEEE C37.121.**
 4. **Comply with NFPA 70.**

2.3 MANUFACTURED UNITS

- A. **Indoor Unit Arrangement:** Single assembly.
- B. **Connections between the primary device and transformer shall be cable, and between the transformer and secondary shall be flexible bus braid unless noted otherwise.**
- C. **Indoor Enclosure:** Steel.
- D. **Skid Mounted:** Mount each shipping group on an integral base frame as a complete weatherproof unit.
- E. **Unit Substation Enclosures Finish:** Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.4 MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION

- A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.
- B. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.
- C. System Voltage: 12.47 kV nominal; 15 kV maximum.
- D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.5 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

- A. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.
 - 1. System Voltage: 12.47 kV nominal; 15 kV maximum.
 - 2. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
 - 3. Main-Bus Rating: 600 A, continuous.
- B. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1. Rating: 600-A continuous duty and load break.
 - 2. Two-Time Duty-Cycle Fault Closing: 25,000 asymmetrical amperes.
 - 3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
 - 4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6. Protective Shields: Cover live components and terminals.
 - a. Fuse Mounts: Single-frame mounted and de-energized when switch is open.
 - 7. Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open. Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
 - 8. Window: Permits viewing switchblade positions when door is closed.
 - 9. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
- C. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.
 - 1. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 2. Indicator integral with each fuse to show when it has blown.
 - 3. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

- D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.6 DRY-TYPE TRANSFORMER SECTION

- A. Description: IEEE C57.12.01, IEEE C57.12.50, and dry-type, two-winding, secondary unit substation transformer.
- B. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.
- C. Style: Indoor, ventilated, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with a 115 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
- D. Cooling System: Class AFA, forced-air cooling, complying with IEEE C57.12.01.
 - 1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
 - 2. Include cooling fans.
- E. Insulation Materials: IEEE C57.12.01, rated 220 deg C.
 - 1. Insulation Temperature Rise: 115 deg C, maximum rise above 40 deg C.
- F. BIL: 95 kV primary side; 30 kV secondary side.
- G. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.
- H. Impedance: between 4 and 7 percent.
- I. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.7 SECONDARY DISTRIBUTION SECTION TERMINAL COMPARTMENT

- A. Low-Voltage Terminal Compartment: Bus.

2.8 SECONDARY DISTRIBUTION SECTION SWITCHGEAR

- A. The secondary distribution section shall be drawout,, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.
 - 1. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.
- B. Switchgear Structure:
 - 1. Match and align the front and back of the switchgear.

2. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
3. Allow the following circuit-breaker functions to be performed when the compartment door is closed:
 - a. Operate manual charging system.
 - b. Open and close the circuit breaker.
 - c. Examine and adjust the trip unit.
 - d. Read the breaker nameplate.
4. Locate instrumentation transformers within the breaker cell, and make front accessible and removable.

C. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
4. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
5. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder line circuit-breaker line connections.
6. Use copper for connecting circuit-breaker line to copper bus.
7. Contact Surfaces of Buses: Silver plated.
8. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
9. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
11. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
12. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

D. Circuit-Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:
 - a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed, and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
 - b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:
 - 1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
 - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.

E. Circuit Breakers:

1. Comply with IEEE C37.13 and UL 1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - a. Normal Closing Speed: Independent of both control and operator.
 - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
 - c. Stored-Energy Mechanism: Manually charged.
 - 1) Operating Handle: One for each circuit breaker capable of manual operation.
 - 2) Electric Close Button: One for each electrically operated circuit breaker.
 - d. Operation counter.
4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 - a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
 - b. Temperature compensation that ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
 - c. Field-adjustable, time-current characteristics.
 - d. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
 - e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 - f. Pickup Points:
 - 1) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
 - 2) Five minimum, for instantaneous-trip functions.
5. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
6. Auxiliary Contacts:
 - a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
 - b. Spare auxiliary switches, at least two, unless other quantity is indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

7. Arc Chutes: Readily removable from associated circuit breaker when it is in "disconnected" position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
 8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
- F. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
- G. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.
- H. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
- I. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.
- J. PLC AUTOMATIC MAIN-TIE-MAIN SYSTEM
1. The system shall be PLC controlled throw over system. In normal operation each main shall be closed and the tie switch open. If the one of the mains loses power, the main shall open and the tie breaker shall close (hold in alternate source). When power returns, the main shall remain open until it is manually transferred back by the users. This process would also remain the same for the second main. If the system is holding in the alternate power, and power has been restored to the open main, and the active main opens, it shall transfer back to the opposite main while keeping the tie breaker closed.
 2. In addition to the automatic transfer sequence the system shall also have the following user selected options controllable by key switches:
 - a. Manual/Automatic Operation
 - b. Open/Closed Transition Transfer
 - c. Auto Retransfer/Hold in Alternate
 - d. A 3-position test switch (Main One, Off, Main Two).
 3. The system shall also have the following indicator lights:
 - a. Auto
 - b. Manual
 - c. Auto Failure
 - d. Source One Available
 - e. Source Two Available
 - f. Source One Open
 - g. Source One Closed
 - h. Source One Fault
 - i. Source Two Open
 - j. Source Two Closed
 - k. Source Two Fault
 - l. Tie Breaker Open
 - m. Tie Breaker Closed
 - n. Tie Breaker Fault.

2.9 LOW-VOLTAGE INSTRUMENT SECTION

- A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.
1. Provide one of the following meters:
 - a. Schneider PM5563
 - b. Eaton PXM1100
 - c. Shark 250 with PROTOCOM BACnet Gateway Kit
 2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 3. Switch-selectable digital display with the following features:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Three-Phase Real Power: Plus or minus 2 percent.
 - e. Three-Phase Reactive Power: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 4. Communications module suitable for remote monitoring of meter quantities and functions. The meter shall be connected to the building's BAS system BACnet server.
 5. **Provide all necessary communication cabling to establish this connection.**
 6. Mounting: Display and control unit that is flush mounted in instrument compartment door at a **height between 4 feet and 6 feet above finished floor.**
- C. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
- D. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:
1. Integral disconnect switch.
 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 3. Indicator light display for protection status.
 4. Form-C contacts rated at 5-A 250-V ac, one N.O. and one N.C., for remote monitoring of protection status.
 5. Surge counter.
- E. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices.
- F. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for duty required.

G. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
4. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
5. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.10 IDENTIFICATION DEVICES

- A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.11 SOURCE QUALITY CONTROL

- A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to NEMA C 37.51.
- B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
 2. Ratios on the rated voltage connection and on tap extreme connections.
 3. Polarity and phase relation on the rated voltage connection.
 4. No-load loss at rated voltage on the rated voltage connection.
 5. Exciting current at rated voltage on the rated voltage connection.
 6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
 7. Applied potential.
 8. Induced potential.
 9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.
 - a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
 10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
- B. Examine roughing-in of conduits and grounding systems 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.
- C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.
- D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.
- B. Install secondary unit substations on existing cast-in-place concrete equipment base(s).
- C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Install the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 ft. (9 m) apart.
 - 2. Install arc-flash warning labels specified in Section 260573.19 "Arc-Flash Studies."
- B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.4 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no

kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.

- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

- A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. General Field Testing Requirements:
 1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
 2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
 4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
 5. Visual and Mechanical Inspection:
 - a. Verify equipment nameplate data complies with Contract Documents.
 - b. Inspect bolted electrical connections for high resistance using one of the following two methods:
 - 1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
 6. Remove and replace malfunctioning units and retest.
 7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.
- D. Switchgear Field Tests:
 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and required area clearances.
 - c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

- d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to the address of the circuit breaker that is used to identify it in microprocessor-communication software.
- e. Verify that current and voltage-transformer ratios correspond to Drawings.
- f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
- g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- h. Inspect insulators for evidence of physical damage or contaminated surfaces.
- i. Verify correct barrier and shutter installation and operation.
- j. Exercise all active components.
- k. Inspect mechanical indicating devices for correct operation.
- l. Verify that filters are in place and vents are clear.
- m. Inspect control power transformers as follows:
 - 1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
 - 2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
 - 3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

- a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.
 - 1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
 - 2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.
- b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.
 - 1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
- c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - 1) Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

- d. Voltage Transformers:
 - 1) Perform secondary wiring integrity test. Verify correct potential at all devices.
 - 2) Verify secondary voltages by energizing the primary winding with system voltage.
 - e. Perform current-injection tests on the entire current circuit in each section of switchgear.
 - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
 - f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.
- E. Instrument Transformer Field Tests:
- 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Verify correct connection of transformers with system requirements.
 - c. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - d. Verify the unit is clean.
 - e. Verify that required grounding and shorting connections provide contact.
 - f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
 - g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
 - h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - 2. Electrical Tests of Current Transformers:
 - a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.
 - b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
 - c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.
 - d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.
 - e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.
 - f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall comply with NETA ATS, Table 100.5. The insulation-resistance value shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
 - g. Perform dielectric-withstand-voltage tests on the primary winding with the secondary grounded. Test voltages shall comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application, the primary winding is considered to have passed the test.
 - h. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to

manufacturer's published data. In the absence of manufacturer's published data, comply with test equipment manufacturer's published data.

- i. Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

- a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
- b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS, Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5.
- c. Perform a polarity test on each transformer to verify the polarity marks or H(1)-X(1) relationship. Polarity results shall agree with transformer markings.
- d. Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.
- e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.
- f. Perform a dielectric-withstand-voltage test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall comply with NETA ATS, Table 100.9. The test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the primary windings are considered to have passed the test.
- g. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with test equipment manufacturer's published data.
- h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

F. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- b. Verify operation of light-emitting diodes, display, and targets.
- c. Record passwords for each access level.
- d. Clean the front panel and remove foreign material from the case.
- e. Check tightness of connections.
- f. Verify that the frame is grounded according to manufacturer's instructions.
- g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Studies."
- h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.

- b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
- c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:
 - 1) Timing Relay:
 - a) Determine time delay.
 - b) Verify operation of instantaneous contacts.
 - 2) Volts/Hertz Relay:
 - a) Determine pickup frequency at rated voltage.
 - b) Determine pickup frequency at a second voltage level.
 - c) Determine time delay.
 - 3) Undervoltage Relay:
 - a) Determine dropout voltage.
 - b) Determine time delay.
 - c) Determine time delay at a second point on the timing curve for inverse time relays.
 - 4) Directional Power Relay:
 - a) Determine minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Determine time delay.
 - e) Verify time delay at a second point on the timing curve for inverse time relays.
 - f) Plot the operating characteristic.
 - 5) Loss of Field (Impedance) Relay:
 - a) Determine maximum reach.
 - b) Determine maximum torque angle.
 - c) Determine offset.
 - d) Plot impedance circle.
 - 6) Current Balance Relay:
 - a) Determine pickup of each unit.
 - b) Determine percent slope.
 - c) Determine time delay.
 - 7) Negative Sequence Current Relay:
 - a) Determine negative sequence alarm level.
 - b) Determine negative sequence minimum trip level.
 - c) Determine maximum time delay.
 - d) Verify two points on the I-two-squared-t curve.
 - 8) Phase Sequence or Phase Balance Voltage Relay:
 - a) Determine positive sequence voltage to close the N.O. contact.

- b) Determine positive sequence voltage to open the N.C. contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close the N.O. contact with sudden application of 120 percent of pickup.
 - e) Determine time delay to close the N.C. contact upon removal of voltage when previously set to rated system voltage.
- 9) Thermal Replica Relay:
- a) Determine time delay at 300 percent of setting.
 - b) Determine a second point on the operating curve.
 - c) Determine pickup.
- 10) Instantaneous Overcurrent Relay:
- a) Determine pickup.
 - b) Determine dropout.
 - c) Determine time delay.
- 11) Time Overcurrent:
- a) Determine minimum pickup.
 - b) Determine time delay at two points on the time current curve.
- 12) Power-Factor Relay:
- a) Determine tripping angle.
 - b) Determine time delay.
- 13) Overvoltage Relay:
- a) Determine overvoltage pickup.
 - b) Determine time delay to close the contact with sudden application of 120 percent of pickup.
- 14) Voltage Balance Relay:
- a) Determine voltage difference to close the contacts with one source at rated voltage.
 - b) Plot the operating curve for the relay.
- 15) Transformer Sudden Pressure Relay:
- a) Determine rate-of-rise or the pickup level of suddenly applied pressure according to manufacturer's published data.
 - b) Verify operation of the 63 FPX seal-in circuit.
 - c) Verify trip circuit to remote operating device.
- 16) Ground Detector Relay:
- a) Determine maximum impedance to ground causing relay pickup.
- 17) Directional Overcurrent Relay:

- a) Determine directional unit minimum pickup at maximum torque angle.
- b) Determine closing zone.
- c) Determine maximum torque angle.
- d) Plot operating characteristics.
- e) Determine overcurrent unit pickup.
- f) Determine overcurrent unit time delay at two points on the time current curve.

18) Frequency Relay:

- a) Verify frequency set points.
- b) Determine time delay.
- c) Determine undervoltage cutoff.

19) Differential:

- a) Determine operating unit pickup.
- b) Determine the operation of each restraint unit.
- c) Determine slope.
- d) Determine harmonic restraint.
- e) Determine instantaneous pickup.
- f) Plot operating characteristics for each restraint.

d. Control Verification:

1) Functional Tests:

- a) Check operation of all active digital inputs.
- b) Check output contacts or SCRs, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
- c) Check internal logic functions used in protection scheme.
- d) For pilot schemes, perform a loop-back test to check receive and transmit communication circuits.
- e) For pilot schemes, perform satellite synchronized end-to-end tests.
- f) For pilot schemes with direct transfer trip (DTT), perform transmit and received DTT at each terminal.
- g) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

G. Dry-Type Transformer Section Field Tests:

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.
- e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
- g. Perform specific inspections and mechanical tests recommended by the manufacturer.
- h. Verify that as-left tap connections are as specified.
- i. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. 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. Calculate polarization index; the value of the index shall not be less than 1.0.
- b. Perform power-factor or dissipation-factor tests on windings according to the test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:
 - 1) 2.0 percent for power transformers.
 - 2) 5.0 percent for distribution transformers.
- c. Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
- d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-up test result exceeding 1.0 percent shall be investigated.
- e. Perform turns-ratio tests at all tap positions. The test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
- f. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.
- g. Measure the resistance of each winding at each tap connection.
- h. Perform an applied-voltage test on all high- and low-voltage windings-to-ground. See IEEE C57.12.91, Sections 10.2 and 10.9. The ac dielectric-withstand-voltage test result shall not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result shall not exceed 100 percent of the ac rms test voltage specified in IEEE 57.12.91, Section 10.2, for one-minute duration. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
- i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

H. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, and grounding.
- c. Verify that all maintenance devices are available for servicing and operating the breaker.
- d. Verify the unit is clean.
- e. Verify that the arc chutes are intact.
- f. Inspect moving and stationary contacts for condition and alignment.
- g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
- h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to manufacturer's published data.
- i. Verify cell fit and element alignment.
- j. Verify racking mechanism operation.
- k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- l. Perform adjustments for final protective-device settings according to coordination study provided by end user.
- m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

- a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
- b. Measure contact resistance across each power contact of the circuit breaker. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Determine long-time pickup and delay by primary current injection. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS, Table 100.7.
- d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
- g. Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic shall be as specified and within manufacturer's published tolerances.
- h. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall conform to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
- i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
- k. Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

I. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
- c. Verify the unit is clean.
- d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

- a. Verify accuracy of meters at cardinal points. Meter accuracy shall be according to manufacturer's published data.
- b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
- c. Verify instrument multipliers. Instrument multipliers shall be according to system design specifications.
- d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

3.7 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Rebalance loads.
 - c. Prepare written request for voltage adjustment by electric utility.
 3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
 4. Report:
 - a. Prepare a written report covering monitoring performed and corrective action taken.
 - b. For each relay and adjustable circuit breaker, tag the device with adjusting technician's initials and the date of the adjustment. Record the settings and file with test records specified in "Field Quality Control" Article.
- B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.
 1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the unit substation.
 2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 3. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 degree C at 30 degrees C.
 4. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between the area of concern and the reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.

- f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of the deficient area.
- 5. Act on inspection results according to the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.8 DEMONSTRATION

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

END OF SECTION 26 1116.11