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PART I - GENERAL1.01 SUMMARY OF WORK

A. Refer to Division 1, Sections 01010, 01011, and 01019 for division of work, sequencing, and other general requirements.

B. The Electrical Contractor shall receive, rig, and install designated pre-purchased and/or owner-furnished items as listed below. Electrical Contractor shall provide unloading and rigging in accordance with requirements of Section 01055. Pre-purchased equipment is as follows:

Section 16425: Low Voltage Service Entrance Switchboard

Section 16427: Low Voltage Switchgear

Section 16428: Generator Paralleling & Closed Transition Low Voltage Switchgear

Section 16429: Load Bank Switchboard

Section 16435: Medium-Voltage Pad Mounted Transformers

Section 16471: Resistive Load Bank

Section 16611: UPS (Parallel Multiple Module with Wet Cell Battery)

Section 16612: Power Distribution Units

Section 16615: Remote Distribution Centers

Section 16622: Standby Diesel Generator

Section 16623: Automatic Transfer Switch without Bypass Isolation

Section 16670: Lightning & Surge Protection Unit

Section 16671: Battery Monitoring System

C. The Electrical Contractor shall provide labor, materials, tools of the trade, and supplies necessary to fully complete the work as indicated on the drawings and described in the project specifications.

D. The Electrical Contractor's work shall include all items described in Division 15 and such other items as are required to establish full, complete, and operational systems.

E. The Electrical Contractor shall provide trade-related cutting, patching, core drilling, and demolition.

F. The Electrical Contractor shall perform his work during normal working hours, except as noted below:

1. Work which involves disruption of service to the building or a portion thereof shall be done between the hours of 1:00 A.M. and 6:00 A.M. Sunday. This work must be coordinated with and approved by the Owner in advance.

2. Work that is being performed within the Computer Room shall be coordinated with and approved by the Owner in advance.

G. The Electrical Contractor shall provide a detailed schedule for his work, consisting of three levels:

1. An overall project schedule designating overall tasks and durations.
 2. A two week look ahead designating specific tasks to be completed on a daily basis.
 3. A comprehensive task list for work involving shutdown of services defining in 15-minute intervals, all tasks and contingencies
- H. The Electrical Contractor shall provide removal, relocation, and reinstallation of selective components presently installed. The work shall include necessary modifications to become fully operational in the new configuration.

1.02 WORK NOT INCLUDED

- A. The following work related to or incidental to the Electrical Work will be furnished and installed under other Divisions of the Specifications:
1. Finish painting except equipment under Electrical Division.
 2. All motors and motor driven equipment shall be furnished and set in place by others and wired by the Electrical Contractor, unless otherwise noted.

1.03 CHANGES IN SCOPE OF WORK

- A. Authorized additions to the scope of the Contract shall be governed by the guidelines of this basic Specification. (Refer to Section 01028 for details).
- B. All new material required due to changes in the scope of work shall be of first quality and shall be submitted to the Engineer and/or Architect for evaluation of acceptability.
- C. "Extra cost" changes in scope of the Contract shall not be undertaken until authorized and documented in writing by the Architect and/or Engineer.

1.04 SEQUENCING OF WORK

- A. Strict adherence to the Master Project Schedule as developed by the Construction Manager.
- B. Refer to Division 1 requirements for additional information.
- C. Specific sequencing shall include the following:
1. Electrical outage at specific times and duration.
 2. Coordination with other subcontractors work.
 3. Strict adherence to the Master Project Schedule as approved by the Owner.

END OF SECTION 16000

PART I - GENERAL1.01 GENERAL REQUIREMENTS

- A. Supplementary Instructions to Bidders, Supplementary Conditions, and Special Conditions and other information contained in the Project Manual shall be incorporated as part of all Sections of this Division of work.
- B. Under this Contract and all sections herein, provide to the Owner, rooms with complete and operative electrical systems and the necessary connections to all electrically operated equipment as outlined herein and as guided by the Contract Drawings.
- C. All labor and materials supplied under this Division shall be the highest quality as judged by the Architect/Engineer.

1.02 DEFINITION OF TERMS IN THIS SECTION

- A. "Provide and install": Arrange for and assume all costs for providing and installing on the job site, complete, operable systems as specified and/or indicated on the Drawings.
- B. "Provide": Used interchangeably with "Provide and Install".
- C. "Install": Utilize trade manpower and expertise to connect items provided by others. Connection includes receiving, rigging, and placement as required.
- D. "Work": Used to include all labor and materials required to satisfy the requirements of the Electrical Division of the Specifications and Drawings.
- E. "Contractor", "Electrical Contractor": Use in this Division refers to the Electrical Trade Contractor, who shall be responsible for all work under the Electrical Division of work.
- F. "Approved", "Approved equal": Acceptable for the use intended and in compliance with all applicable codes, regulations, and satisfies contractual obligations relative to function and quality as judged by the Architect, Owner, and Engineer.
- G. "Responsible", "Responsibility": Assume all consequences or contingencies, monetary and otherwise, under this basic Contract, with no additional costs passed on to others by Contractor.
- H. "Neat workmanlike manner", "Properly installed": Installed in accordance with all applicable codes and good recommended practice, such as would be instructed in a trade school. The Architect/Engineer reserves the right to judge acceptability.
- I. "Power wiring": All wiring carrying the operating current from an electrical power source to electric operated devices, operating at 100 volts or more.
- J. "Control wiring": All wiring, other than power wiring, from electric operated equipment to control devices and between various control devices. Control wiring shall include wiring for monitoring and alarm systems.
- K. "Furnish": Electrical Contractor shall furnish on the job site for use by others.

1.03 CODES, REGULATIONS, AND CONDITIONS GOVERNING WORK

- A. Bid price shall reflect the investigation of all conditions governing work, including the cost of all modifications to systems, should they be necessary, to meet all code and local regulations and all conditions that will affect work. The following shall be included in the investigation of conditions:
1. Contract Drawings and Specifications
 2. Conditions at site
 3. Constraints and conditions due to partial Owner occupancy during construction
 4. All applicable codes and local regulations
 5. Anticipation of weather conditions during the construction period
 6. Local regulations or requirements of the local Electrical and/or Building Inspector
 7. Anticipation of strikes or forced work stoppages.
- B. The Electrical Contractor shall be totally responsible for all assumptions, omissions, and errors in the investigation of conditions.
- C. All work shall be done in strict accordance with the latest accepted edition of all governing codes and regulations including, but not limited to, the following:
1. NFPA 70 - National Electrical Code
 2. NFPA 101 - Life Safety Code
 3. NFPA 72 - Signaling System
 4. BOCA Building Code
 5. All state and local codes and enforced regulations affecting work
- D. In no way shall the information on the Drawings or in the Specifications preclude code compliance. Where work indicated on the Contract Documents exceeds code requirements, the work as outlined in the Contract Documents shall take precedence.
- E. Secure and keep current all licenses, permits, approvals, or certificates required for work under this Division of the Contract.
- F. Conduct all testing as required by the inspecting authorities.

1.04 DRAWING INTERPRETATION

- A. Contract Drawings are diagrammatic and intended to outline basic engineering and systems design, therefore, do not show minor details and accessories. Because a minor component is not shown, shall not relieve the Contractor of responsibility for furnishing and installing all such items necessary to provide complete, operative, and properly installed systems to the Owner under the basic Contract. If there are any doubts as to work required, the Contractor shall obtain a clarification from the Engineer in the bid stage.
- B. The Contract Drawings show the intended location of equipment; however, the Contractor shall be responsible for any minor adjustments or relocations necessary due to choice of equipment and coordination conflicts. All equipment relocations must be submitted to the Architect/Engineer for approval.
- C. The project drawings, specifications, and other documents are complimentary. Items required by one shall designate requirement by the other, whether explicitly stated or not. Where documents conflict, the work of the more stringent nature shall be required.

1.05 RECORD DRAWINGS

- A. An accurate record shall be kept of all electrical work, showing the exact final location of all access doors, ducts, pull boxes, junction boxes, concealed feeders, outlets, switches, motors, appliances, panelboards, and equipment when not as shown on the Contract Drawings.
- B. All changes made by Addenda or Change Order shall be incorporated on the Record Drawings.
- C. Record Drawings shall be turned over to the Engineer for approval at the time of notification of completion of the project.
- D. Refer to the Project Manual for General Conditions, Supplementary General Conditions, and additional requirements.

1.06 SCHEDULING AND COORDINATION OF WORK

- A. Work shall be scheduled to meet the Construction Manager's overall construction schedule, as well as coordinate with the schedules of all other Contractors and Subcontractors, so that work progresses smoothly with no delays.
- B. Refer to the Project Manual for basic sequence of Construction.
- C. Clearances and access spaces shall be maintained around equipment. Installations shall be coordinated with the equipment and system of all other trades. It shall be the Contractor's responsibility to eliminate any conflicts that arise due to failure to coordinate.
- D. Permitted use, location, and type of all anchors, supports, sleeves, and other materials that shall be cast into concrete, must be verified with the Architect and are subject to approval.

1.07 MATERIALS AND SUBMISSION FOR APPROVAL

- A. Refer to Project Manual for basic guidelines, covering submission of materials for approval.
- B. Provide the proper materials necessary to complete all work included in this Division of the Contract. Additional Costs incurred in any Division of work consequent to substitution of materials, shall be investigated prior to submission. All cost penalties shall be the responsibility of the Contractor regardless of approval of such materials.
- C. The materials specified herein are indicative of both the characteristics and quality of materials necessary to satisfy Contract responsibilities; type and quality standards will be strictly upheld in consideration for approval of equipment and the Architect/Engineer's judgment of compliance will be final.
- D. Requests for substitutions will not be considered until after award of Contract, and then will be accepted only from the Contractor through the Architect. All requests must be in writing or in the form of material submittals with special cover letter giving credits available or reasons for the proposed substitution. The Contractor shall be responsible for supplying, on request, information and samples of both specified and substituted materials.
- E. The Architect, Engineer, and Owner reserve the right to refuse approval of materials and equipment used on the job that, in their opinion, does not meet the standards outlined herein. Only after documentation of approval, where approval is required, shall materials be ordered and installed on this project. All installed materials requiring approval that have not been approved, shall be removed and replaced as directed by the Architect.

- F. Architect/Engineer's review of Shop Drawings will cover materials only. Quantities and dimensions necessary to satisfy the Contract and to coordinate with other trades will be the Contractor's responsibility.
- G. Material approvals shall be obtained in time so material can be manufactured and delivered to the job site in coordination with project work schedules. Additional costs to all trades arising because of material not being available when necessary shall be the responsibility of the Contractor causing the delay.
- H. Material submissions shall contain the following information in reiteration and in addition to the information required in the Project Manual:
 - 1. Project name
 - 2. Specification section and paragraph submitted under
 - 3. Manufacturer
 - 4. Manufacturing materials, gauge, and finish
 - 5. Electrical requirements and characteristics
 - 6. Performance and operating characteristics
 - 7. List or denote all accessories and options included
 - 8. Delete all listed accessories and options not included
 - 9. Indicate all special equipment required for a complete system to be supplied by others, and by whom they will be supplied.
 - 10. Indicate any deviations from specification and other constraints that may affect the work of any contractor.
- I. All related equipment necessary to comprise a complete system shall be submitted in a folder with each page identified. Indicate when submitting an incomplete system in which some components will be submitted under separate cover.
- J. The following procedures shall apply:
 - 1. Transmit each submittal with form accepted by Architect/Engineer.
 - 2. Sequentially number the transmittal forms. Resubmittals to have original number with an alphabetic suffix.
 - 3. Identify Project, Architect/Engineer, Contractor, Subcontractor or supplier; pertinent Drawing sheet and detail number (s), and specification Section number, as appropriate.
 - 4. Apply Trade Contractor's or Supplier's stamp, signed or initialed certifying that review, verification of Products required, field dimensions, adjacent construction Work, and coordination of information, is in accordance with the requirements of the Work and Contract Documents.
 - 5. Schedule submittals to expedite the Project, and deliver in accordance with the Project Manual.
 - 6. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.
 - 7. Provide space for Contractor and Architect/Engineer review stamps.
 - 8. Revise and resubmit submittals as required, identify all changes made since previous submittal.
 - 9. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.
- K. Within three days after date of Contractor Agreement and/or Purchase Order, submit complete list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.
- L. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

- M. Within ten calendar days after date of Contractor Agreement and/or Purchase Order, submit shop drawings in the form of one reproducible transparency and one blue line reproduction, each item listed on the schedule.
- N. Within ten calendar days after the date of Contractor Agreement and/or Purchase Order, submit product data as follows:
 - 1. Submit only pages that are pertinent; mark each copy of standard printed data to identify pertinent products, reference to Specification Section and Article number. Show reference standards, performance, and controls; component parts; finishes; dimension; and required clearances.
 - 2. Modify manufacturer's standard schematic drawings and diagrams to supplement standard information and to provide information specifically applicable to the Work. Delete information not applicable.
- O. Review submittals and shop drawings prior to transmittal; determine and verify field measurements, field construction criteria, manufacturer's catalogs numbers, and conformance of submittal with requirements of Contract Documents. Contractor review and submission indicates that the Supplier certifies that he (it) has investigated and verified all materials, and specification criteria and that he has checked and coordinated same with the requirements of the work and the Contract Documents and that there are no deviations except as specifically noted in this submission, and hereby submits for review in accordance with requirements of the General Conditions.
- P. Coordinate submittals with requirements of Work and of Contract Documents.
- Q. Sign or initial each sheet of shop drawings and product data. Each sample label to certify compliance with requirements of Contract Documents. Notify Owner in writing at time of submittal of any deviations from requirements of Contract Documents.
- R. Do not fabricate products or begin work that requires submittal until return of submittal with Architect/Engineer acceptance.
- S. Make resubmittals under procedures specified for initial submittals; identify changes made since previous submittal.
- T. When specified in individual specification Sections, submit manufacturer's printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, in quantities specified for Product Data.
- U. Identify conflicts between manufacturer's instructions and Contract Documents.
- V. When specified in individual specification Sections, submit manufacturer's certificate to Architect/Engineer for review, in quantities specified for Product Data.
- W. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
- X. Certificates may be recent or previous test results on material or Product, but must be acceptable to Construction Manager.

Y. Shop Drawings and Data indicated are to be provided for the following by the Electrical Contractor:

Submittal Description

Shop Drawings

Building Automation Shop Drawings
 Coordination Shop Drawing
 Data and Voice Cables Shop Drawings
 Electrical Shop Drawings
 Fire Detection Shop Drawings
 Lightning Protection Shop Drawings
 Security Shop Drawings
 Site Utility Shop Drawings
 Underground Grounding Shop Drawings
 Weatherproof Enclosure Shop Drawings

Submittals

Electrical

Automatic Transfer Switch
 Battery Monitoring System
 Busduct/Busway
 Cable Trays
 Closed Circuit Television System
 Computer Power Centers
 Conduits & Fittings
 Data Cabling System
 Data Center Monitoring System
 Disconnect Switches
 Dry Type Transformers
 Electric Heat Trace
 Electrical Identification
 Electrical Manholes
 Electrical Supports and Anchors
 Electrical Switchboards
 Electrical Switchgear
 Electronic Entry Control Systems
 Enclosed Switches
 EPO System
 Exterior Lighting
 Facility Security System
 Feeder and Plug-In Busway
 Generator Paralleling Switchgear & Controls
 Interior Lighting
 Intrusion Detection Equipment
 Lamps

Lightning & Surge Protection Unit (TVSS) (SPD)
 Lightning Protection
 Liquid Detection and Alarm System
 Load Bank Switchboard
 Low Voltage Manual Transfer Switch
 Motor Control Center
 Outlet Boxes
 Pad-Mounted Transformers
 Panelboards
 Plate Covers
 Power Distribution Units (PDU)
 Pull and Junction Boxes
 Radio and Public Address Systems
 Receptacles
 Remote Distribution Centers (RDC)
 Resistive Load Bank
 Service Entrance Switchboard
 Sound Attenuation Specialties
 Standby Generator
 Static Transfer Switch
 UPS Battery System
 UPS System
 Variable Frequency Drives
 Wall Switches
 Wires and Cables
 Wiring Devices

Fire Detection	Air Sampling Fire Detection Fire Detection and Alarm System Very Early Smoke Detection System
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Reports

Electrical Test Reports
 Short Circuit and Coordination Study Report
 Testing & Inspection of Sprayed-On Fireproofing Test Report

- Z. Shop drawings and submittals shall be reviewed and returned within ten working days. The following meanings shall apply:
1. Approved means that fabrication, manufacture, or construction may proceed, providing submittal complies with Contract Documents. Supplier assumes sole responsibility for the required compliance. No response is required of the Supplier.
 2. Approved as Noted means that fabrication, manufacture, or construction may proceed, provided submittal is amended and resubmitted to comply with Construction Manager's notations and the Contract Documents, or the Supplier confirms in writing that he will do so. If for any reason

contractor can not confirm compliance with notations, Supplier shall resubmit as described for submittals stamped Rejected.

3. Rejected means that submittal does not comply with Contract Documents, and that fabrication, manufacture, or construction as submitted must not proceed under any circumstances. Submittals stamped Rejected are not permitted on job site.
4. For transparencies stamped Approved, or Approved as Noted, or Comments Attached, Supplier shall provide the six copies of the submittal as required for field distribution.
5. Supplier receipt of shop drawings or data stamped Rejected shall not be the basis of a claim for extension or delay, with regard to delivery of equipment or material.

1.08 WORKMANSHIP

- A. All work shall be done by competent Electricians, skilled in the portion of work they will be engaged in on this project. All work shall be in accordance with the highest standards of established practice in the electrical trade, and shall produce the most stable, durable, and presentable results.
- B. All work under this Division, judged below standard by the Architect/Engineer, shall be brought up to standard at no cost to the Owner.

1.09 QUALITY ASSURANCE/CONTROL OF INSTALLATION / INFORMATION

- A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
- B. Comply fully with manufacturer's instructions, including each step in sequence.
- C. Should manufacturer's instructions conflict with Contract Documents, request clarification from the Owner before proceeding.
- D. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Perform work by persons qualified to produce workmanship of specified quality.
- F. Secure Products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion or disfigurement.
- G. When specified in individual specification Sections, require material or Product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test, adjust, and balance of equipment and as applicable, and to initiate instructions when necessary.
- H. All equipment provided under this Division shall be set up, and adjusted following the manufacturer's instructions or requirements for proper operation and maintenance.
- I. Where equipment manufacturer's instruction or requirements conflict with information on the Drawings or in the Specifications, the Engineer shall be advised. The Engineer shall resolve conflicts and the solution shall be instituted under the basic Contract with no additional cost to the Owner.
- J. The Owner, or his operating personnel, shall be instructed in the location and use of all equipment and systems installed under the Electrical Division of Work. This shall include the services of a man familiar with all equipment and systems for a minimum of two days and maximum of one week.

- K. Submit to the Engineer for approval, four copies of Maintenance Manuals for all major equipment and systems. Maintenance Manuals, when approved, will be turned over to the Owner for his use. The Manuals shall contain installation, operating, and maintenance instructions, and spare parts list.

1.10 CUTTING AND PATCHING

- A. Execute cutting, fitting, and patching to complete Work and to:
 - 1. Fit the several parts together to integrate with other work
 - 2. Uncover work to install ill-timed work
 - 3. Remove and replace defective and non-conforming work
 - 4. Remove sample of installed work for testing
 - 5. Provide openings in elements of Work for penetrations of mechanical and electrical work
- B. Maintain weather tight conditions at all times, arrange temporary protection as required to provide same.
- C. Inspect existing conditions, including elements subject to damage or movement during cutting and patching.
- D. After uncovering, inspect conditions affecting performance of work.
- E. Beginning of cutting or patching means acceptance of existing conditions.
- F. Provide supports to assure structural integrity of surroundings; devices and methods to protect other portions of Project from damage.
- G. Execute work by methods to avoid damage to other work, and which will provide proper surfaces to receive patching and finishing.
- H. Employ authorized and qualified installer to perform cutting and patching for moisture-resistant elements and sight-exposed surfaces.
- I. Cut rigid materials using masonry saw or core drill. Pneumatic tools are not allowed without prior approval.
- J. Restore work with new products in accordance with requirements of Contract Documents.
- K. Fit work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- L. At penetrations of fire-rated wall, ceiling or floor construction, completely seal voids with-fire rated material, full thickness of the construction element.
- M. Refinish surfaces to match adjacent finishes; for continuous surfaces, refinish to nearest intersection; for an assembly, refinish entire unit.

1.11 FIRE STOPPING

- A. The Electrical Contractor shall provide fireproof firestopping materials and accessories for all electrical penetrations using fireproofing materials per ASTM E814 to achieve a fire rating as required by applicable codes.
- B. Submit product data: Provide data on product characteristics, performance and limitation criteria.
- C. Submit manufacturer's installation instructions: Indicate preparation and installation instructions.

- D. Submit manufacturer's certificate: Certify that products meet or exceed specified requirements.
- E. Conform to applicable code for fire resistance ratings and surface burning characteristics.
- F. Do not apply materials when temperature of substrate material and ambient air is below 60° F.
- G. Maintain this minimum temperature before, during, and for 3 days after installation of materials.
- H. Sequence Work to permit firestopping materials to be installed after adjacent and surrounding work is complete.
- I. The acceptable manufacturers are as follows:
 - 1. 3M Fire Barrier Products
 - 2. Domtar Gypsum
 - 3. USG
 - 4. Dow
 - 5. Or approved equal.
- J. Firestopping Material: Single component caulk
 - 1. CP 25N/S for wall and ceiling applications (3M)
 - 2. CP 258S/L for floor applications (3M)
 - 3. Fire Halt - Sealant (Domtar)
 - 4. Fire Stop Foam and Sealant (Dow)
- K. Penetrations:
 - 1. FB-2000 for wall and floor penetrations (3M)
 - 2. CP25WB Caulk (3M)
 - 3. Fire Halt Sealant (Domtar)
 - 4. Fire Stop Foam and Sealant (Dow)
- L. Cable Tray:
 - 1. KBS Seal Bags as manufactured by International Protection Coatings.
- M. Fire Safing Material:
 - 1. Thermafiber (USG)
 - 2. Mineral Wool (Dow)
- N. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter, which may affect bond of firestopping material.
- O. Remove incompatible materials that affect bond.
- P. Apply materials in accordance with manufacturer's instructions.
- Q. Apply firestopping material in sufficient thickness to achieve rating to uniform density and texture.
- R. Install material at walls or partition openings that contain penetrating sleeves, electrical duct, cable tray, conduit, and other items requiring firestopping.
- S. Clean Work under provisions of Section 01700.

T. Clean adjacent surfaces of firestopping materials.

1.12 UNLOADING AND RIGGING

- A. Execute unloading, rigging and storage to complete work and to:
 - 1. Fit the several parts together to integrate with other work.
 - 2. Remove and replace defective and non-conforming work.
 - 3. Remove materials and equipment used for operations, repair, replace and/or restore any items damaged as a result of operations.
- B. Inspect existing conditions, including elements subject to damage or movement during unloading and rigging.
- C. Beginning of unloading or rigging means acceptance of existing conditions.
- D. Provide insurance coverage sufficient to cover the cost for immediate replacement and all costs required, should any equipment or portion of the project be damaged during unloading and rigging.
- E. Provide insurance coverage for total replacement value of all products, materials and/or equipment stored.
- F. The contractor shall, to the fullest extent possible, indemnify and hold harmless the Owner, Architect/Engineer and landlord from and against all claims, damages, losses and expenses resulting from the performance of the work.
- G. Provide supports to assure structural integrity of surroundings, and devices and methods to protect other portions of project from damage.
- H. Execute work by methods to avoid damage to other work, and which will provide proper support during rigging and unloading.
- I. Contractor shall receive at tailgate, all designated products, material and/or equipment.
- J. Contractor shall unload products, material and/or equipment, and store until ready for rigging in place
- K. Contractor shall transport, move, and rig equipment to designated location, upon direction of Construction Manager.
- L. Contractor shall coordinate his work with other trade contractors as required, to ensure the proper placement and setting of equipment.
- M. Transport and handle products in accordance with manufacturer's instructions
- N. Promptly inspect shipments to assure products are undamaged. Notify the Owner and transportation vendor in writing of any damage noted
- O. Provide equipment and personnel to handle products by method to prevent soiling, disfigurement and damage.
- P. Store and protect products in accordance with manufacturer's instructions with seals and labels intact and legible. Store sensitive products in weather tight, climate controlled enclosures.

1.13 PRODUCTS

- A. Products: Means new material, machinery, components, equipment, fixtures, and systems forming the Work. Does not include machinery and equipment used for preparation, fabrication, conveying, and erection of the Work. Products may also include existing materials or components required for reuse.
- B. Provide interchangeable components of the same manufacturer, for similar components.
- C. Transport and handle Products in accordance with manufacturer's instructions.
- D. Promptly inspect shipments to assure that Products comply with requirements, quantities are correct, and Products are undamaged.
- E. Provide equipment and personnel to handle Products by method to prevent soiling, disfigurement, or damage.
- F. Arrange storage of Products to permit access for inspection. Periodically inspect to assure Products are undamaged and are maintained under specified conditions.

1.14 PROTECTION, MAINTENANCE, AND MAKING READY FOR ACCEPTANCE

- A. All equipment and systems provided under this Division shall be protected, maintained, and kept in good repair until final acceptance by the Owner. Only first class, undamaged equipment in good operating condition will be accepted.
- B. Use of all equipment supplied under this Division is prohibited until Owner's final acceptance except for testing, by special permission, or as allowed by the "Temporary Services" section of the Specifications.
- C. All equipment supplied under this Division shall be freshly lubricated just before final inspection. Furnish to the Owner all necessary devices for lubrication of the equipment.
- D. All concealed hangers and supports shall be painted with rust inhibitive enamel. Finish painting of all exposed work will be by others.
- E. All materials subject to moisture damage shall be stored indoors in a controlled environment as necessary to prevent condensation in the materials.

1.15 STARTING SYSTEMS

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify Owner seven days prior to start-up of each item.
- C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions that may cause damage.
- D. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
- E. Verify wiring and support components for equipment are complete and tested.
- F. Execute start-up under supervision of responsible Contractor's personnel in accordance with manufacturer's instructions.

- G. When specified in individual specification Sections, require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.
- H. Submit a written report that equipment or system has been properly installed and is functioning correctly.

1.16 TESTING AND ACCEPTANCE OF EQUIPMENT

- A. Arrange and conduct all requested testing necessary to demonstrate to the Architect/Engineer, the proper operation of all equipment supplied under this Division. Proper operation shall include the following:
 - 1. Operating characteristics as specified
 - 2. All accessories and options installed and operational
 - 3. Total system and individual components operational as specified and per manufacturer's published information
 - 4. No excess noise and vibration, as judged by the Engineer
- B. Provide all labor, materials, and instruments necessary to conduct all required testing. Test findings shall be recorded and neatly typed in a report and submitted to Engineer in triplicate.
- C. All tests which must be witnessed by inspecting authorities shall be prearranged with the Inspector before notifying the Architect/Engineer. The Contractor shall notify the Engineer not less than forty-eight hours in advance of all tests. The Contractor shall be responsible for modifications or repairs necessary to satisfy all required testing.
- D. Preliminary tests and adjustments shall be conducted to minimize the amount of time required for adjustments and repairs during the actual final testing.
- E. Motor testing shall be conducted on all motors. Testing and data to be tabulated in the report shall be as follows:
 - 1. Equipment name or description
 - 2. Motor manufacturer's available nameplate data including: rpm, HP, phase, voltage, full load amperes, safety factor, power factor, manufacturer's name, motor type and/or model number
 - 3. Motor test readings shall be taken at normal load and shall include amperes for each phase, phase-to-phase voltage at motor, and at starter or disconnect switch terminals.

$$\text{Percentage} = \frac{\text{load test amperes (average)}}{\text{full load amperes (nameplate)}}$$
 - 4. Motor starter nameplate data shall include manufacturer, model, size, and ampere rating of overload heaters installed.
 - 5. Motor feeder breaker and/or disconnect switch data shall include manufacturer of fuses installed, and branch circuit wire size.

1.17 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of Substantial Completion.
- B. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.

- C. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner's personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at scheduled times, at designated location.
- E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

1.18 CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for Architect/ Engineer's inspection.
- B. Provide submittals to Architect/Engineer that are required by governing or other authorities.

1.19 FINAL CLEANING

- A. Execute final cleaning prior to final inspection.
- B. Clean equipment and fixtures to a sanitary condition.
- C. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.20 ADJUSTING

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

1.21 PROJECT RECORD DOCUMENTS

- A. Maintain on site, one set of the following record documents; record actual revisions to the Work:
 - 1. Contract Drawings.
 - 2. Specifications.
 - 3. Addenda.
 - 4. Change Orders and other Modifications to the Contract.
 - 5. Reviewed shop drawings, Product data, and samples.
- B. Store Record Documents separate from documents used for construction.
- C. Record information concurrent with construction progress.
- D. Specifications: Legibly mark and record at each Product section description of actual Products installed, including the following:
 - 1. Manufacturer's name and product model and number.
 - 2. Product substitutions or alternates utilized.
 - 3. Changes made by Addenda or Modifications.
- E. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:
 - 1. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.

2. Field changes of dimension and detail.
3. Details not on original Contract Drawings.

F. Submit documents to Architect/Engineer with claim for final Application for Payment.

1.22 OPERATION AND MAINTENANCE DATA

- A. Submit two sets prior to final inspection, bound in 8-1/2 x 11 inch text pages, bound with durable plastic covers.
- B. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", title of project, and subject matter of binder when multiple binders are required.
- C. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
- D. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified type on 24-pound white paper.
- E. Part I: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.
- F. Part II: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:
 1. Significant design criteria.
 2. List of equipment.
 3. Parts list for each component.
 4. Operating instructions.
 5. Maintenance instructions for equipment and systems.
 6. Maintenance instructions for finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
- G. Part III: Project documents and certificates, including the following:
 1. Shop drawings and product data.
 2. Test and start-up reports.
 3. Manufacturer's Certificates.
 4. Photocopies of warranties.
- H. Submit one copy of completed volumes in final form three days prior to final inspection. This copy will be returned, with Architect/Engineer comments. Revise content of documents as required prior to final submittal.

1.23 GUARANTEES AND WARRANTIES

- A. The Electrical Contractor shall be responsible for replacing or repairing all work performed, or materials furnished under this Division that proved defective within a one year guarantee period, unless otherwise noted. Responsibility shall include the cost of temporary services while repairs are made, and all consequential costs to other trades caused by the defective material or workmanship.
- B. Provide to the Owner a list of all guarantees and warranties on specific pieces of equipment supplied under this section.

- C. Provide duplicate notarized copies.
- D. Execute and assemble documents from subcontractors, suppliers, and manufacturers.
- E. Provide Table of Contents and assemble in binder with durable plastic cover.
- F. Submit prior to final Application for Payment.
- G. For items of work delayed beyond date of Substantial Completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

END OF SECTION 16010

PART I - GENERAL

- 1.01 The Contractor shall engage the services of a qualified professional engineer to perform a short circuit, Arc Flash and protective device coordination study. The study shall be performed in strict accordance with these specifications. The Contractor shall also provide the appropriate Arc Flash signage for all electrical panels and switchboards.

PART II - SHORT CIRCUIT STUDY

- 2.01 The Contractor shall provide a short circuit study for the electrical distribution system. The study shall include the calculation of three phase bolted fault values and phase-to-ground fault values at every point of application of a protective device on the system. Momentary and interrupting duty values shall be calculated.
- 2.02 The short circuit calculations shall be performed on digital computer.
- 2.03 The short circuit study report must include a complete index of fault bus identifications. A system diagram indicating system configuration and the fault bus locations shall be provided in the study.
- 2.04 Provide a complete print out of the results of the calculations.
- A. Momentary duty fault values shall be tabulated for both three phase and phase-to-ground faults including: bus identification, bus L-L voltage, symmetrical fault current values, symmetrical fault kVA values, and X/R ratio at each fault bus.
- B. Interrupting duty fault values shall be tabulated for both three phase and phase-to-ground faults including: bus values, symmetrical fault kVA values, X/R ratio at each fault bus, asymmetry factor at each fault bus, and the associated asymmetrical fault value at the bus.
- 2.05 Manufacturer's published interrupting/withstand capabilities shall be compared to calculated fault current values to determine acceptability of each protective device installed in the system. Tabulation shall be provided detailing the comparison.
- 2.06 The short circuit study shall report any deficiencies in interrupting capabilities and include recommendations for correcting such deficiencies.
- 2.07 The intention of the design of the generator/ Utility transfers at the MS switchboards is to provide closed transition- soft loading. The calculated fault current must be made at the worst case of the utility and both generators in parallel. 2740a @ 34 kv at the transformer primary has been quoted by the utility but must be verified.
- 2.08 The coordination study must be made for three different utility transformer considerations. The initial transformer will be a 2500 kva (5.75% Z), the next growth will be a 3000 kva (6% Z) and the final growth will be a 3750 kva (7.1% Z).

PART III - PROTECTIVE DEVICE COORDINATION

- 3.01 The contractor shall provide a protective device coordination study for all protective devices installed on the electrical distribution system.
- 3.02 The coordination study shall begin with the first upstream utility protective device and continue down through the distribution system to the first device on each feeder that does not have adjustable trip characteristics.

- 3.03 Time-current coordination curve sheets shall be developed on log-paper (K&E 48 5258) utilizing manufacturer's published time current characteristics. Key coordination elements shall be plotted to demonstrate the level of coordination provided.
- A. Transformer damage characteristics as specified in American National Standards Institute/Institute of Electrical and Electronics Engineers guidelines and inrush points shall be plotted to demonstrate the level of protection provided. Cable insulation withstand curves shall also be plotted to demonstrate protection provided.
 - B. Each curve sheet must have a single line diagram indicating the portion of the system being plotted.
 - C. Each curve sheet must be accompanied by a detailed narrative explaining the coordination provided, and any compromises made between protection and selectivity.
- 3.04 The coordination study report shall provide complete tabulations of all protective devices ratings and settings. Recommendations shall be provided to improve coordination where necessary.
- 3.05 All generator & utility protective relay settings must also be provided. These settings must be coordinated and approved by the local Utilities.

PART IV – ARC FLASH STUDY

- 4.01 The resultant data from the short circuit coordination study should be fed into the equations described by either NFPA 70E-2000 or IEEE Standard 1584-2002. These equations will produce the necessary flash protection boundary distances and incident energy to determine the minimum PPE requirement.
- 4.02 Appropriate warning signs shall be provided for all switchboards, panels, disconnects and starters.

PART V - EXECUTION

- 5.01 Six copies of a bound report shall be submitted for review and approval at the completion of the short circuit and coordination study. The report shall contain all of the items required by these specifications.
- 5.02 Time-current coordination curve sheets may be reduced to 8½" x 11" size for inclusion in the report. However, full size curve sheets shall be provided, not necessarily bound, with each copy of the report.
- 5.03 The contractor shall warrant that errors and omissions in the study or report shall be corrected without charge to the Owner when so found within 12 months from acceptance of the report.
- 5.04 Copies of the approved study shall be included in the manuals required by Division 1, Section 01700, Contract Close-Out.

END OF SECTION 16020

PART I - GENERAL

- 1.01 Application Publication: The publication listed below forms a part of this specification to the extent referenced. The publication is referred to in the text by the basic designation only.
- A. National Electrical Testing Association: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, Latest edition.

PART II - QUALIFICATIONS AND RESPONSIBILITIES

- 2.01 The Contractor shall engage the services of a qualified testing organization to provide final inspection, testing, calibration, and adjusting on the electrical distribution system as defined in this contract. The organization shall be independent of the supplier, producer, or installer of the equipment.
- 2.02 Testing, inspection, and calibration shall be performed by an Engineering Technician, certified by a national organization, with a minimum of five years experience inspecting, testing and calibrating electrical distribution equipment, systems, and devices. Information on the testing organization and qualifications of the Certified Engineering Technician shall be submitted to the engineer for approval prior to the start of work.
- 2.03 The Contractor shall supply to the testing organization complete sets of approved shop drawings, coordination study, settings of all adjustable devices, and other information necessary for an accurate inspection and evaluation of the system prior to the performance of any tests. The testing organization shall submit a test procedure for each item of equipment to be tested on this project for approval after the evaluation of the system and equipment has been determined. No testing shall be performed until after the test procedures have been submitted to and approved by the Engineer.

PART III - INSPECTIONS

- 3.01 An inspection of the installed equipment shall be performed by the testing organization to verify that the distribution equipment installed, and to be tested is the equipment as denoted on the approved shop drawings. The inspection shall check the equipment designations, device characteristics, special installation requirements, and applicable code of requirements and other conditions that may affect the successful, safe performance and operation of the system.
- 3.02 The installed equipment shall be compared to the approved shop drawings after the installation and a report developed stating any discrepancies.

PART IV - TESTING

- 4.01 The testing organization shall perform tests on each item of distribution equipment contained in this contract in accordance with the latest edition of the National Electrical Testing Association's (NETA) Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems, dated 1987, as revised.
- 4.02 Field Acceptance Testing shall be accomplished on each item of electrical distribution equipment installed or connected to a part of this contract. This shall include, but is not limited to:
- A. All power and distribution transformers.
- B. All medium voltage circuit breakers, switches, and assemblies.
- C. All adjustable trip low voltage circuit breakers.

- D. All metal enclosed switchgear and switchboard assemblies.
 - E. All protective relays and associated current and potential transformers.
 - F. All switchgear metering instrumentation devices and associated current and potential instrumentation transformers.
 - G. Grounding systems.
 - H. Ground Fault systems.
 - I. Automatic transfer switches and other emergency connected devices.
 - J. Generators.
 - K. Low voltage power busway.
- 4.03 Systems shall be energized or otherwise placed in service only after completion of all required tests and an evaluation of the test results has been completed.

PART V - SYSTEM FUNCTION TESTS

- 5.01 Each system provided in this contract, and covered by this section of specifications, shall be function tested to ensure total system operation. The Contractor shall verify that all systems interface correctly with all related systems.
- 5.02 After the manufacturers complete their individual start-up checks, services and testing, the Contractor shall provide a total power system load test.
- 5.03 Load banks shall be provided with a minimum rating which equals or exceeds the redundant rating of the UPS system. The load banks shall be capable of continuous operation in the environment where it will be located. The load bank shall be provided with integral overcurrent and over temperature alarms. Controls shall be provided to select load levels of 0%, 25%, 50%, 75%, and 100% of the ratings specified, without de-energizing the load bank. All cables and connectors shall be provided to connect the load bank to the UPS output switchboard. The contractor shall be responsible for connecting the load bank.
- 5.04 Recording type test equipment shall be connected to the output of the UPS system during the entire load test. Three phase output voltage and output frequency shall be monitored. Voltage sensitivity shall be less than 0.5% of nominal system frequency. Response time shall be 10 msec or less. Recorded test data shall indicate all voltage and frequency deviations from nominal values. The test data shall be summarized, certified, and provided to the engineer at the conclusion of the load test. All cables, sensors, and accessories shall be provided to accurately measure the specified parameters. The test equipment shall bear valid calibration data for the test equipment to the engineer for approval prior to the system load test.
- 5.05 A service representative of the manufacturer of the UPS system, the engine-generators and the engine-generator switchgear shall be present during the system load test. The representatives shall be qualified to service the equipment and make necessary checks and adjustments to ensure proper operation of their respective system.
- 5.06 The system load test shall be conducted at the direction of the engineer.
- 5.07 Any failure during the system load test shall be corrected immediately. The test procedure in progress at the time of failure shall be restarted. The contractor shall warrant that errors and omissions in the study or report

shall be corrected without charge to the Owner when so found within 12 months from acceptance of the report.

- 5.08 The engineer reserves the right to accept or reject test data that does not conform to the manufacturer's data or is not obtained in accordance with these specifications.

PART VI - DOCUMENTATION

- 6.01 Provide six bound copies of certified test reports for review and approval. Copies of the approved report shall be included in the manuals required in Section 16010, paragraph 1.22.

END OF SECTION 16030

PART I - GENERAL1.01 GENERAL METHODS AND MATERIALS

- A. Provide complete wiring and raceway systems as indicated on the drawings and specified herein. All wire and raceway shall be continuous and in accordance with code requirements.
- B. Materials and installation shall be in accordance with NFPA codes and standards with special attention to NFPA-70, "National Electric Code" latest accepted edition.

PART II - PRODUCTS2.01 GENERAL WIRING MATERIALS

- A. All electrical equipment shall be UL listed and labeled unless otherwise noted.
- B. All conductors shall be copper.
- C. Approved connectors for splices and joints in wiring 600 volts or less are as follows:
 - 1. Number 10 AWG and smaller: UL approved, solderless connectors with nylon shell with internal spring, Ideal Industries Wing Nut connectors or approved equal.
 - 2. Number 8 AWG and larger: UL approved clamp type terminals, Burndy "Quick link" or approved equal, with approved insulating method.
- D. Splices shall be permitted only for terminating wires to pig-tail leads. All splices shall be directly accessible.

2.02 RACEWAY MATERIALS

- A. All raceway products shall be UL listed and labeled for their intended use.
- B. Raceway products include conduit, cable tray, and busway systems. Refer to individual sections for more information.

PART III - INSTALLATION3.01 GENERAL WIRING METHODS

- A. Wiring on the Drawings is to show switching intent and circuit to panel. Exact device interconnections, routing, quality of conductors and code required raceway size, where not otherwise noted, shall be the Contractor's responsibility with exact method being his option, provided methods comply with the intent of contract documents and all code regulations.
- B. Leave sufficient slack wire in outlet boxes to allow removal and necessary work room for device removal and replacement and per NEC requirements.
- C. Connections to electrical equipment shall be made using approved connecting devices. Screw or lug connections may be used for wire Number 8 AWG or larger. Lugs shall be rated for cable material and the cable size to be connected. It shall be the Contractor's responsibility for verifying that all electrical equipment, to which he must wire, is ordered with the proper size wiring lugs.
- D. Entire installation shall be in accordance with National Electrical Manufacturers Association recommended practices as a minimum.

- E. Equipment manufacturer's installation instructions shall be followed except where they conflict with other installation instructions and/or "good practices". If there is a conflict, the Contractor shall include the most costly installation in his bid or request a resolution prior to bidding.

3.02 RACEWAY METHODS

A. Prohibited Locations

1. Electrical Metallic Tubing (EMT) shall not be installed underground or in concrete.
2. PVC shall not be installed in air plenums.

B. Required Locations

1. Rigid steel conduit or PVC conduit, schedule 40 or heavier, for all conduits installed underground or in concrete. Stub-ups from below concrete shall be rigid steel.
2. All outdoor feeder conduits and indoor exposed locations subject to damage or below 6 foot in vehicle or traffic areas shall be galvanized rigid steel, rigid aluminum, or IMC.
3. Exposed rigid non-metallic conduit shall be used only in locations where specifically noted.
4. Flexible conduit shall be used only for dry locations.
5. Liquid-tight flexible conduit shall be used in place of flexible conduit in damp or wet locations. This shall include all connections to pumps.
6. Surface metal raceways shall be used only in finished areas where surface raceways are required by building conditions, and where specifically noted on the drawings.
7. EMT shall be used in all locations not noted above.

C. Installation

1. In general, all new raceways in finished areas shall be concealed unless specifically noted otherwise.
2. Where exposed conduits are specifically required, they shall be installed parallel with or at right angles to the building lines, and not installed diagonally.
3. Any minor changes in the location of raceways from those shown on the drawings shall be made without extra charge if so directed by the Architect before installation.
4. Coordinate with other work including metal and concrete work, as necessary to interface installation of electrical raceways and components.
5. Install horizontal raceway runs above water and steam piping.
6. For conduits one inch and larger, hickey bends are not acceptable. Either manufactured elbows or bends fabricated in a bending machine must be used.
7. Where a conduit enters a box or other fitting through a knockout, an approved double locknut and insulating bushing must be provided. All conduits shall be equipped with insulating bushings at all outlets, pull boxes, panel, etc.
8. Complete installation of electrical raceways before starting installation of cables/wires within raceways.
9. Install flexible conduit for motor connections and for other electrical equipment connections where subject to movement and vibration.
10. Install liquid-tight flexible conduit for connection of motors and for other electrical equipment where subject to movement and vibration, and also where subjected to one or more of the following conditions:
 - a. Below raised floor throughout computer room and computer room ancillary rooms.
 - b. Moist or humid atmosphere where condensate can be expected to accumulate.
 - c. Corrosive atmosphere.
 - d. Subjected to water spray.
 - e. Subjected to dripping oil, grease, or water.
11. Flexible conduit connections to motors shall include one 90° bend.
12. All conduits shall be cleaned by pulling a swab through the conduit before pulling in wires.

13. Branch raceway runs are shown schematically. Except where exact routing is indicated, branch circuit raceways may be grouped, and the actual routing of branch circuit raceways may be altered, providing actual locations are properly entered on the "As-Built" drawings.
14. Conduit connections between outlet boxes less than 24" apart on opposite sides of a wall shall be made with a loop of flexible conduit (no nipples).
15. Grout around all conduits at ceiling, floor, and wall penetrations to provide air-tight seal. All penetrations through slabs and fire-rated walls shall be sealed using a fire-rated material approved by the Engineer.
16. Provide roof jack at all penetrations. Coordinate roof jack type and installation with Construction Manager. Equipment must be compatible with required roof guarantee.
17. Conduits or raceways that penetrate the computer room boundary at any location other than through a RF line filter shall be bonded at the penetration. The bonds shall be #2 copper, unless detailed otherwise on the drawings, and connected to the equipment potential ground system.
18. Support conductors in vertical raceways in accordance with NEC 300-19.

D. Cleaning

1. Upon completion of installation of raceways, inspect interiors of raceways, remove burrs, dirt, and construction debris.

END OF SECTION 16050

PART I - GENERAL1.01 SECTION INCLUDES

- A. Indoor busway and fittings

1.02 RELATED SECTIONS

- A. Section 01010: Summary of Work - Pre-Purchased Equipment
- B. Section 01018: Owner Furnished Items
- C. Section 16000: Electrical Summary of Work

1.03 REFERENCES

- A. NEMA AB 1 - Molded Case Circuit Breakers
- B. NEMA BU 1 - Busways
- C. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies
- D. NEMA KS 1 - Enclosed Switches
- E. NFPA 70 - National Electrical Code

1.04 SUBMITTALS

- A. Shop Drawings: Vendor in conjunction with the electrical contractor shall create detailed shop drawings reflecting existing conditions and the following:
 - 1. Indicate ratings, dimensions and finishes.
 - 2. Include dimensioned layout diagram, installation details and locations of supports and fittings such as firestops and weatherseals.
 - 3. Include details of wall and floor penetrations.
- B. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.05 PROJECT RECORD DOCUMENTS

- A. Record actual locations of busway routing and plug-in units.

1.06 OPERATION AND MAINTENANCE DATA

- A. Maintenance Data: NEMA Bulletin BU1.1 which will be provided for installation and for future maintenance instructions.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

1.08 REGULATORY REQUIREMENTS**D. A. Underwriter's Laboratories Listing.**

1. All straight lengths, fittings, and plug-in units shall be UL listed.
2. This listing shall include mounting of the busway in any position (i.e. horizontal, flatwise, edgewise, and vertical) without derating.

1.09 PRE-INSTALLATION CONFERENCE

- A. Convene one week prior to commencing work of this Section.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site.
- B. Accept busway on site in factory containers. Inspect for damage.
- C. Protect from moisture by using appropriate coverings. Store in dry interior locations.

1.11 FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on shop drawings.

PART II - PRODUCTS**2.01 MANUFACTURERS****A. Acceptable manufacturers are as follows:**

1. General Electric, Spectra Series
2. Westinghouse, Model Pow-R-Way
3. Square D, Model I-Line
4. or approved equal

2.02 GENERAL

- A. Furnish and install a complete low impedance prefabricated busway distribution system as shown on the plans and details
- B. Busway shall be 480 volts, 3 phase, 3 wire with 50% capacity integral ground bus.
- C. The ampere ratings, approximate footage, fitting, plug-in units etc., are shown on the plan.
- D. The electrical contractor shall be responsible for routing the busway to coordinate with the other trades. Final field measurements shall be made by the contractor prior to release of the busway for fabrication.

2.03 SHORT CIRCUIT RATING AND TESTS

- A. The short-circuit rating of the busway shall be 200,000 for service entrance busway and 100,000 for all other busways, RMS symmetrical amperes as indicated on the drawings, which is the ultimate anticipated short-circuit current available at the source.

- B. The short-circuit rating of the busway shall be determined according to UL standards No. 857. This rating must be based upon actual tests at the rated short-circuit current.

2.04 BASIC CONSTRUCTION

A. Housing

1. The busway integrated housing shall be constructed of all aluminum to reduce hysteresis and eddy current losses and shall be provided with a suitable protective finish of ANSI 49 gray epoxy paint. Ground resistance values shall exceed NEC 250 requirements.
2. The busway housing shall be totally enclosed non-ventilated for protection against mechanical damage and dust accumulation.
3. The totally enclosed housing shall be manufactured by the busway manufacturer. Modifications of busway to make it totally enclosed by other than the busway manufacturer voids the UL manifest. Busway so modified is unacceptable.
4. The plug-in busway shall be furnished in an Indoor enclosure. The feeder busway shall be furnished in an indoor enclosure.

B. Joint

1. The busway joint shall be of the one-bolt type which utilizes a high strength steel bolt(s) and Belleville washer to maintain proper pressure over a large contact surface area.
2. The bolt shall be torque indicating, fully insulated and at ground potential.
3. The bolt shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access shall be required to only one side of the busway for tightening joint bolts.
5. On busway 800A and above, it shall be possible to remove any joint connection assembly to allow electrical isolation or physical removal of a busway length without disturbing adjacent busway lengths.

C. Bus Bars

1. The bus bars shall be plated their entire length. Bus bars shall be silver-flashed copper.
2. Each bus bar shall be insulated over its entire length with Class B (130° C) rated insulating material.
3. The temperature rise at any point in the busway shall not exceed 55° C rise above ambient temperature when operating at rated load current.
4. Both feeder and plug-in busway (800A and above) shall be of sandwich construction, meaning no air gap shall exist between bus bars except at plug-in openings and joints.

D. Plug-In Openings

1. On plug-in busway there shall be five dead front, hinged cover type plug-in openings on each side of ten-foot lengths.
2. All openings shall be usable simultaneously.
3. Busway shall be installed so plugs are side mounted to permit practical use of all ten plug-in openings.
4. Each phase position of a plug-in opening shall be individually insulated.
5. It shall be possible to inspect the plug-in opening and bus bars prior to the installation of the plug-in unit.

E. Support of Busway

1. Hanger spacing shall be noted on layout drawings. Hangers shall be placed adjacent to each joint and not exceed 10'-0" spacing on horizontal runs.

2. Plug-in/Feeder type Busway shall be approved for hanger spacing of up to 10'-0" on horizontal runs and 16'-0" when vertically mounted.
3. Plug-in busway shall be sway braced as detailed on the plans to counteract the unbalanced weight of plug-ins, ladders, etc.
4. Outdoor Busway shall be approved for hanger spacing of up to 5'0" on horizontal and vertical runs.

F. Voltage Drop

1. The voltage drop (input voltage minus output voltage) specified shall be based on the busway operating at full rated current and at stabilized operating temperature in 30°C ambient temperature.
2. The three-phase, line-to-line voltage drop shall not exceed 2.4 volts per hundred feet at 40% power factor concentrated load which condition may exist during motor starting.
3. The line-to-line voltage drop shall not exceed 3.5 volts per hundred feet at the load power factor which produces maximum voltage drop in the busway.

2.05 FITTINGS

- A. Provide manufacturer's standard and custom-fabricated fittings to facilitate the installation using compact minimum sizing.
- B. Label every piece of bus to maintain proper phasing. All housing width and depth dimensions are to be identical to straight lengths.
- C. Provide cable tap boxes where a run of busway is fed by cable and conduit. Utilize design to permit removal of up to three side walls for cable access/entrance and for greater flexibility and installation ease.
- D. Provide a universal stub for field connections.
- E. Provide switchboard/switchgear stub for full factory coordination to other electrical equipment.
- F. Provide power take-offs using tap joints to accept bolted power take-off devices up to 1600 amps.
- G. Provide end boxes where required to terminate busway runs.
- H. Provide wall, ceiling, and floor flanges to be used to close wall openings when busway runs pass through walls, ceilings and floors.
- I. Include provisions for expansion lengths as follows:
 1. Thermal expansion $\pm 1"$
 2. Building expansion: $\pm 2"$
- J. Provide transposition lengths to minimize duct run requirements. A transposition length is used to rotate the phase arrangement in any dimension from three feet through ten feet.
- K. Provide busway field check pieces/replacement pieces as required. A field check piece is a length of busway inserted into a run after the major portion of that run has been installed. This permits the release of straight lengths and portions of the run with known dimensions long before final dimensions are set.

2.06 HANGERS

- A. Vertical Mounting: Spring hangers are to be furnished to support the busway at each floor. When the floor-to-floor span is over 16 feet, support for the spring hanger should be provided. The quantity of springs required is based on busway weight and must be coordinated by the vendor and Electrical Contractor.
- B. Horizontal Mounting: Furnish one for every 10 feet. Design for ½" diameter drop rods. Provide additional mount at each fitting and change of direction.

PART III - EXECUTION**3.01 PREPARATION**

- A. Do not install busway when installation location is not protected from moisture.
- B. Verify that vendor shop drawings are complete and materials received are in agreement.

3.02 INSTALLATION

- A. Install busway and accessories in accordance with manufacturer's instructions and additional instructions which are detailed in NEMA publication BU1.1 provided with the equipment by the electrical manufacturer.
- B. Install busduct and accessory devices as indicated in accordance with requirements of the NEC and the National Electrical Association's "Standard of Installation", and in accordance with recognized industry practices to ensure that products serve the intended functions.
- C. Coordinate busduct installation work with work of other trades. Install bus runs straight and plumb, and align horizontal runs to be parallel to the building structural axis.
- D. Using hanger accessories provided by the manufacturer, supply and install pendant hardware and lateral bracing to resist torsional movements caused by connecting conduits and unbalanced plug-in devices. Not less than 1/3 of the supports should be of the movement-resisting type.
- E. Take special care in making up bus joints to properly place shims, spacers, lock washers, and other jointing hardware as the manufacturer intended. Tighten joint bolt (s) to recommended torque requirements.
- F. Install busway length with expansion fitting at each location where busway run crosses building expansion joint. Include expansion joints so that bus as fixed longitudinally will have the range of movement necessary to accommodate that of the building structure and thermal changes with load.
- G. Install plug-in devices in the prescribed manner required by the manufacturer. Be sure that all captive covers for unused tap openings are closed.
- H. Install busway with integral fire stops located where busway penetrates fire-rated walls and floors. Seal around opening to maintain fire rating of wall or floor.
- I. Provide concrete curb around interior floor penetrations.

3.03 FIELD QUALITY CONTROL

- A. Prior to energizing, check for ground and phase-to-phase faults; correcting any deficiencies.
- B. Field inspection and testing to be completed prior to placing busway into service.

END OF SECTION 16051

PART I - GENERAL1.01 PROVISIONS

- A. Raceways for future wires and cables shall be enclosed in a raceway.
- B. All raceways shall be concealed unless noted otherwise.
- C. Separate raceway systems shall be provided for each of the various wiring systems (power monitoring, telephone, etc.).

1.02 RELATED REQUIREMENTS

- A. All provisions of the Contract including Project Manual requirements, apply to work of this section.

1.03 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of raceway systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer: A firm or individual with not less than 3 years of successful experience in installation of raceways similar to those required for this project.
- C. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to raceways.
- D. UL Compliance and Labeling: Comply with applicable portions of UL safety standards pertaining to electrical raceways systems; and provide products and components which have been UL-listed and labeled.
- E. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of raceway systems.

1.04 SUBMITTALS

- A. Product Data: Submit Manufacturer's data including specifications, installation instructions, and general recommendations, for each type of raceway required. Include data substantiating that materials comply with requirements listed in part two.
- B. Shop Drawings: Submit shop drawings under provisions of Section 16010.

PART II - PRODUCTS2.01 CONDUIT STANDARDS

- A. Rigid Steel Conduit: FS WW-C-0581 and ANSI C80.1.
- B. Rigid Aluminum, Conduit: FS WW-C-540 and ANSI C80.5.
- C. Intermediate Steel Conduit: FS WW-C-581.
- D. Rigid Metal Conduit Fittings: FS W-F-408.
- E. Electrical Metallic Tubing (EMT): FS WW-C-563 and ANSI C80.3.

- F. EMT Fittings: FS W-F-408.
- G. Flexible Metal Conduit: FS WW-C-566.
- H. Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 1, and Style A.
- I. Liquid-Tight Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 3, Style G.
- J. PVC Conduit and Tubing Fittings: NEMA Std. Pub No. TC 8, DB120, match to conduit/tubing type and material.
- K. PVC and ABS Plastic Utilities Duct Fittings: Match to duct type and material.

2.02 METALLIC CONDUIT AND RACEWAYS

- A. Galvanized Rigid Steel (GRS) Conduit: Standard galvanized steel pipe sizes with threaded joints approved for use as electrical raceways.
- B. Rigid Nonmetallic Conduit: Polyvinyl chloride, Schedule 40 heavy wall, UL labeled. Provide separate grounding conductor full length of conduit.
- C. Flexible Conduit: Galvanized steel or aluminum. Provide ground bonding conductor full length of circuit inside conduit. Fittings shall be of same manufacture as conduit.
- D. Flexible Conduit, Liquid-tight: Bonded type, constructed of single strip, continuous interlocked double-wrapped steel, galvanize inside and out, with copper bonding tape ground bonding conductor inside conduit in addition to integral bonding tape. Flex conduit below computer raised flooring shall be Electri-flex "Liquitite" type LA (or equivalent) with blue outer jacket.
- E. Surface Metal Raceways: Wiremold, or Walkerdut, of size required for wiring, furnished with all associated hardware.
- F. Electrical Metallic Tubing: Zinc-coated steel.
- G. Unions: Erickson couplings. Running threads will not be allowed.
- H. Coupling and Connectors (EMT): Extruded steel, set-screw type. Below raised floor systems or in wet locations use rain tight type, employing a split corrugated ring and tightening nut. Provide pre-insulated bushings in all connectors.
- I. Intermediate Metallic Conduit: Steel, UL labeled, in standard pipe sizes with screwed joints for electrical raceway use. Finish shall be zinc-coated steel or hot-dip galvanized. Manufacturer shall be Allied or equivalent.

2.03 NONMETALLIC CONDUIT AND DUCTS

- A. General: Provide nonmetallic conduit, ducts and fittings of types, sizes, and weights (wall thickness) for each service indicated. Where types and grades are not indicated, provide proper selection determined by installer to fulfill wiring requirements, and comply with applicable portions of NEC for raceways.
- B. Conduit, Tubing and Duct Accessories: Provide conduit, tubing and duct accessories of types, sizes, and materials complying with manufacturer's published product information, which mate and match conduit and tubing.

2.04 PULL AND JUNCTION BOXES

- A. Pullboxes and Junction Boxes: Metal construction, conforming to National Electrical Code, with screw-on or hinged cover.
- B. Flush-Mounted Pullboxes: Provide overlapping covers with flush-head cover retaining screws, prime coated.

PART III - EXECUTION**3.01 PROHIBITED LOCATIONS**

- A. Electrical metallic tubing shall not be installed underground or in concrete.
- B. PVC shall not be installed in air plenums.

3.02 REQUIRED LOCATIONS

- A. Rigid Steel conduit or PVC conduit, Schedule 40 or heavier, for all conduits installed underground or in concrete. Stub-ups from below concrete shall be rigid steel.
- B. All outdoor feeder conduits and indoor exposed locations subject to damage or below 6 foot in vehicular or traffic areas shall be galvanized rigid steel, rigid aluminum, or IMC.

3.03 INSTALLATION

- A. All electrical raceways shall be installed to accommodate the requirements of gravity drain systems.
- B. Any minor changes in the location of raceways from those shown on the approved shop drawings shall be made without extra charge if so directed by the Engineer before installation.
- C. Coordinate with other work including structural and mechanical work, as necessary to facilitate installation of electrical raceways and components.
- D. Install horizontal raceway runs in separate lifts to allow for compaction of fill.
- E. Where a conduit enters a vault or other assembly, the conduit shall enter at a 90° angle to the face of the assembly.
- F. Install duct bank in accordance with the following:
 - 1. Utilize premanufactured spacers to maintain separation between conduits. Space in accordance with manufacturer's recommendations.
 - 2. Join nonmetallic conduit using adhesive as recommended by manufacturer.
 - 3. Wipe nonmetallic duct dry and clean before joining. Apply full even coat of adhesive to entire area inserted in fitting. Allow joint to cure for a minimum of 20 minutes.
 - 4. Stagger nonmetallic conduit joints vertically in concrete encasement 6 inches minimum.
 - 5. Band ducts together before placing concrete. Securely anchor duct to prevent movement during concrete placement.
 - 6. Place concrete encasement under provisions of Division 2.
 - 7. Provide minimum 3 inch concrete cover at bottom, top, and sides of ductbank.
 - 8. Risers from horizontal duct runs shall be either galvanized rigid conduit, plastic jacketed or concrete-encased PVC conduit.
 - 9. Provide nylon pull rope in each empty duct.

10. Swab duct. Use suitable caps to protect installed duct against entrance of dirt and moisture.
11. Backfill trenches under provisions of Division 2.
12. Interface installation of underground warning tape with backfilling. Install tape 6 inches below finished surface or paving.

G. Contractor shall install pull rope with swab at full diameter of conduit and pull through conduit in presence of Construction Manager to verify that there are no blockages.

3.04 CLEANING

- A. Upon completion of installation of raceways, inspect interiors of raceways and vaults, remove burrs, dirt, and construction debris.

END OF SECTION 16105

PART I - GENERAL1.01 PROVISIONS

- A. All wires and cables shall be enclosed in a raceway.
- B. All raceways shall be concealed unless noted otherwise.
- C. Separate raceway systems shall be provided for each of the various wiring systems (power monitoring, telephone, etc.).

1.02 RELATED REQUIREMENTS

- A. All provisions of the contract including, Division 1, apply to work specified in each section of this Division 16. In addition, the sections listed below (if part of this specification) apply to work related to this section.
 - 1. Section 16010: General Requirements for Electrical Work
 - 2. Section 16120: Wire and Cable
 - 3. Section 16131: Pull and Junction Boxes
 - 4. Section 16134: Outlet Boxes
 - 5. Section 16190: Supporting Devices
 - 6. Section 16195: Identification

1.03 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of raceway systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer: A firm or individual with not less than 3 years of successful experience in installation of raceways similar to those required for this project.
- C. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to raceways.
- D. UL Compliance and Labeling: Comply with applicable portions of UL safety standards pertaining to electrical raceways systems; and provide products and components that have been UL-listed and labeled.
- E. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of raceway systems.

1.04 SUBMITTALS

- A. Product Data: Submit Manufacturer's data including specifications, installation instructions and general recommendations, for each type of raceway required. Include data substantiating that materials comply with requirements listed in part two.

PART II - PRODUCTS2.01 STANDARDS

- A. Rigid Steel Conduit: FS WW-C-0581 and ANSI C80.1.
- B. Rigid Aluminum, Conduit: FS WW-C-540 and ANSI C80.5.

- C. Intermediate Steel Conduit: FS WW-C-581.
- D. Rigid Metal Conduit Fittings: FS W-F-408.
- E. Electrical Metallic Tubing (EMT): FS WW-C-563 and ANSI C80.3.
- F. EMT Fittings: FS W-F-408.
- G. Flexible Metal Conduit: FS WW-C-566.
- H. Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 1, and Style A.
- I. Liquid-Tight Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 3, Style G.
- J. PVC Conduit and Tubing Fittings: NEMA Std. Pub No. TC 3, match to conduit/tubing type and material.
- K. PVC and ABS Plastic Utilities Duct Fittings: ANSI NEMATC 9, match to duct type and material.

2.02 MATERIALS

- A. Galvanized Rigid Steel (GRS) Conduit: Standard galvanized steel pipe sizes with threaded joints approved for use as electrical raceways.
- B. Rigid Nonmetallic Conduit: Polyvinyl chloride, Schedule 40 heavy wall, UL labeled. Provide separate grounding conductor full length of conduit.
- C. Flexible Conduit: Galvanized steel or aluminum. Provide ground bonding conductor full length of circuit inside conduit. Fittings shall be of same manufacture as conduit.
- D. Flexible Conduit, Liquid tight: Bonded type, constructed of single strip, continuous interlocked double-wrapped steel, galvanize inside and out, with copper bonding tape ground bonding conductor inside conduit in addition to integral bonding tape. Flex conduit below computer raised flooring shall be Electri-flex "Liquitite" type LA (or equivalent) with blue outer jacket.
- E. Surface Metal Raceways: Wiremold or Walkerdect, of size required for wiring, furnished with all associated hardware.
- F. Electrical Metallic Tubing: Zinc-coated steel.
- G. Unions: Erickson couplings. Running threads will not be allowed.
- H. Couplings and Connectors (EMT): Extruded steel, set-screw type. Below raised floor systems or in wet locations use rain tight type, employing a split corrugated ring and tightening nut. Provide pre-insulated bushings in all connectors.
- I. Intermediate Metallic Conduit: Steel, UL labeled, in standard pipe sizes with screwed joints for electrical raceway use. Finish shall be hot dip galvanized.

2.03 NONMETALLIC CONDUIT AND DUCTS

- A. General: Provide nonmetallic conduit, ducts and fittings of types, sizes and weights (wall thickness) for each service indicated. Where types and grades are not indicated, provide proper selection determined by installer to fulfill wiring requirements, and comply with applicable portions of NEC for raceways.

- B. Conduit, Tubing and Duct Accessories: Provide conduit, tubing and duct accessories of types, sizes, and materials complying with manufacturer's published product information, which mate and match conduit and tubing.

PART III - EXECUTION

3.01 PROHIBITED LOCATIONS

- A. Electrical metallic tubing shall not be installed underground or in concrete.
- B. PVC shall not be installed in air plenums.

3.02 REQUIRED LOCATIONS

- A. Rigid Steel conduit or PVC conduit, schedule 40 or heavier, for all conduits installed underground or in concrete. Stub-ups from below concrete shall be rigid steel.
- B. All outdoor and indoor feeder conduits and indoor exposed conduit locations subject to damage or below 6 foot areas shall be galvanized rigid steel or IMC.
- C. Exposed rigid nonmetallic conduit shall be used only in location where specifically noted.
- D. Flexible conduit shall be used only for dry locations.
- E. Liquid tight flexible conduit shall be used in place of flexible conduit in damp or wet locations. This shall include all connections to pumps.
- F. Surface metal raceways shall be used only in finished areas where building conditions requires surface raceways, and where specifically noted on the drawings.
- G. Electrical metallic tubing shall be used in all locations not noted above.

3.03 INSTALLATION

- A. In general, all new raceways in finished areas shall be concealed unless specifically noted otherwise.
- B. Where exposed conduits are specifically required, they shall be installed parallel with or at right angles to the building lines, and not installed diagonally.
- C. Any minor changes in the location of raceways from those shown on the drawings shall be made without extra charge if so directed by the Architect before installation.
- D. Coordinate with other work including metal and concrete work, as necessary to interface installation of electrical raceways and components.
- E. Install horizontal raceway runs above water and steam piping.
- F. For conduits one inch and larger, hickey bends are not acceptable. Either manufactured elbows or bends fabricated in a bending machine must be used.
- G. Where a conduit enters a box or other fitting through a knockout, an approved double lock nut and insulating bushing must be provided. All conduits shall be equipped with insulating bushings at all outlets, pull boxes, panel, etc.

- H. Complete installation of electrical raceways before starting installation of cables/wires within raceways.
- I. Install flexible conduit for motor connections and for other electrical equipment connections where subject to movement and vibration.
- J. Install liquid-tight flexible conduit for connection of motor and for other electrical equipment where subject to movement and vibration, and also where subjected to one or more of the following conditions:
 - 1. Below raised floor throughout computer room and computer room ancillary rooms.
 - 2. Moist or humid atmosphere where condensate can be expected to accumulate.
 - 3. Corrosive atmosphere.
 - 4. Subjected to water spray.
 - 5. Subjected to dripping oil, grease, or water.
- K. Flexible conduit connections to motors shall include one 90° bend.
- L. All conduits shall be cleaned by pulling a swab through the conduit before pulling in wires.
- M. Branch raceway runs are shown schematically. Except where exact routing is indicated, branch circuit raceways may be altered, providing actual locations are properly entered on the "As-built" drawings.
- N. Conduit connections between outlet boxes less than 24" apart on opposite sides of a wall shall be made with a loop of flexible conduit (no nipples).
- O. Grout around all conduits at ceiling, floor, and wall penetrations to provide airtight seal. All penetrations through slabs and fire-rated walls shall be sealed using a fire-rated material approved by the Engineer.
- P. Provide roof jack at all roof penetrations. Coordinate roof jack type and installation with General Contractor. Equipment must be compatible with required roof guarantee.
- Q. Conduits or raceways that penetrate the computer room boundary at any location other than through an RF line filter shall be bonded at the penetration. The bonds shall be #2 copper, unless detailed otherwise on the drawings, and connected to the equipment potential ground systems.
- R. Support conductors in vertical raceways in accordance with NEC 300-19.

3.04 CLEANING

- A. Upon completion of installation of raceways, inspect interiors of raceways, remove burrs, dirt, and construction debris.

END OF SECTION 16110

PART I - GENERAL1.01 WORK INCLUDED

- A. Conduit and couplings
- B. Flexible conduit

1.02 REFERENCE STANDARDS

- A. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
- B. ANSI C80.3 U.L. Standard 360 - Electrical Metallic Tubing, Zinc-Coated
- C. ANSI/NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies
- D. FS WW-C-563 - Electrical Metallic Tubing
- E. FS WW-C-566 - Specification for Flexible Metal Conduit
- F. FS WW-C-581 - Specification for Galvanized Rigid Conduit
- G. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing

PART II - PRODUCTS2.01 MATERIALS AND COMPONENTS

- A. Conduit: Electrical metallic tubing; rigid steel (3/4" minimum).
- B. Couplings: Threaded, liquid tight. Die cast fittings are not acceptable.
- C. Flexible Conduit:
 - 1. General Equipment: Flexible plastic jacketed with liquid tight connectors (3/4" minimum).
 - 2. Below raised floor computer equipment Branch wiring flexible liquid tight metallic conduit for computer grade identification (1/2 minimum). Feeders to UPSs or PDUs shall be EMT.
- D. Running threads are not acceptable; three piece unions shall be used where applicable.

PART III - EXECUTION3.01 INSTALLATION

- A. The Electrical Contractor shall furnish all necessary conduit supports as shown or implied on the drawings. All conduit shall be securely fastened in place by means of approved supports and fastenings, and shall be installed with conduit fittings of types adaptable for the particular location. Conduit runs on walls, columns or partitions shall be secured in place with hot dipped, galvanized, malleable iron conduit half straps and back spacers, as manufactured by Appleton Electric Company, O.Z. Gedney, or equal.
- B. Conduit half straps attached to masonry or concrete walls, floors, or partitions shall be secured in place with expansion screw anchors. Anchors shall be as manufactured by Ackerman-Johnson, or equal.

- C. Exposed conduit shall be run parallel or at right angles to the building lines, and whenever conduit enters outlet boxes, panels, pullboxes, switches, or conduit fittings, an offset shall be formed on the conduit, and method of fastening same shall be subject to the direction and approval of the Architect. Exposed conduit shall only occur 10'-0" above finished floor.
- D. Where groups of vertical and horizontal exposed parallel conduits occur, they shall be braced with clamps and brackets equal in quality to those manufactured by Unistrut.
- E. The end of all conduit shall be carefully reamed, and shall be made to butt in the center of the coupling. The use of running threads for conduit connections at couplings, fittings, or boxes shall be prohibited.
- F. Make galvanized conduit joints and connections thoroughly water-tight and rustproof using "KOPR/Shield", as manufactured by Thomas & Betts Co., Inc., or equal.
- G. All conduit work in areas where hung ceilings are provided shall be run concealed in the ceilings. All vertical conduit drops to switches, receptacles, or outlets shall be run in the walls, unless specifically noted otherwise on the plans or specified herein.
- H. Conduit work in areas where no hung ceiling is provided shall be run exposed unless specifically noted otherwise. In exposed and hung ceilings, all lighting, receptacle and switch branch circuits shall be run in EMT. A six foot whip of "MC" flexible conduit shall be connected to lighting fixtures. In stud walls, vertical drops shall be "MC" flexible conduit. In finished or unfinished block walls, vertical drops shall be EMT conduit run in the walls.
- I. Conduits entering outlet boxes, cabinets, and sheet metal enclosures when not terminated in a threaded hub, shall be secured in place by two (2) locknuts and terminated with an insulated bushing.
- J. All conduit fittings, unless specified otherwise herein, shall be manufactured by Appleton Electric Company, or equal. Conduit fittings to liquid-tight conduit shall be liquid tight, compression fittings.
- K. All metal conduit enclosures, and raceways for conductors shall be mechanically jointed together to form a continuous electrical conductor, and shall be so connected to all electrical boxes, cabinets, and fittings as to provide effective electrical continuity, and firm mechanical assembly.
- L. All conduits and fittings shall be carefully examined before being installed, and all pieces having splits, breaks, blisters, or other defects, shall not be used.
- M. All conduit shall be so installed so as not to interfere with ceiling inserts, ceiling mounted lighting fixtures, etc. A minimum separation of 6" shall be required where conduit is run parallel to or across steam, hot water, or condensate pipes.
- N. In no case shall conduit be fastened to other pipes or installed in such a manner as to prevent the ready removal of other pipes for repair or replacement.
- O. Spacing of straps, clamps or hangers for supporting rigid conduits from ceiling or walls shall not be greater than distance specified:

<u>Conduit Size</u>	<u>Spacing of Supports</u>
Up to 1"	6'
1¼" to 1½"	8'
2", 2½", 3", and 4"	10'

- P. Supports for electrical metallic tubing shall be as per Article 342.30 of NEC.
- Q. All conduit fittings 2" and larger shall be the Mogul type.
- R. Liquid-tight flexible metallic conduit with continuous copper bonding conductor shall be used for connections to motors, and at other locations where vibration or movement is encountered, and under raised floors in computer rooms. Liquid-tight flexible metallic conduit shall be "Sealtite" type UA, or "O.Z." type UAG, or approved equal for general equipment. Computer grade "blue" liquid - tight flexible metal conduit shall be Anaconda Sealtite, Type CW, or approved equal for general equipment. Computer grade, liquid-tight, flexible metal conduit shall be Anaconda Sealtight, type CW blue, or approved equal.
- S. All bending of conduit shall be done with an approved bending device, and any conduit crushed or deformed in bending shall be replaced. All bends shall be avoided so far as possible, and all unavoidable bends and offsets shall be made with the largest radius possible. All 90° bends in conduit larger than one inch size shall be manufactured elbow and when four inch size and larger shall be long radius elbows. No more than three 90° bends shall be allowed in any one conduit run. When more bends are necessary, a pull box shall be installed. Pull boxes shall be installed every 100 feet.
- T. Conduit passing through building expansion joints shall be provided with suitable expansion compensation fittings.
- U. Critical control systems such as EPO systems, etc. shall not utilize flexible conduit. EMT only shall be used - no substitutes shall be allowed.
- V. All conduit and fittings shall form a continuous metallic path and shall be suitable and acceptable for use as an equipment ground.
- W. All empty conduits shall be identified and shall have a 12 gauge galvanized steel drag wire or nylon line installed.

END OF SECTION 16111

PART I - GENERAL1.01 SECTION INCLUDES

- A. Cable trays.
- B. Cable tray accessories.

1.02 REFERENCES

- A. NEMA VE 1 - Cable Tray Systems.

1.03 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 01300.
- B. Indicate tray type, dimensions, support points, and finishes.
- C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART II - PRODUCTS2.01 MANUFACTURERS

- A. M.P. Husky
- B. B-Line Systems
- C. GS Metals
- D. Substitutions: Under provisions of Section 01600.

2.02 LADDER-TYPE CABLE TRAYS

- A. Tray: NEMA VE 1; Class 20C.
- B. Material and Finish of Tray, Fittings, and Accessories: Steel, hot-dipped galvanized after fabrication or aluminum.
- C. Inside Width: As indicated.
- D. Inside Depth: As indicated.
- E. Straight Section Rung Spacing: 6 inches on center.
- F. Inside Radii of Fittings: 24 inches or as indicated.
- G. Accessories and Fittings: Manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.

2.03 TROUGH-TYPE CABLE TRAYS

- A. Tray: NEMA VE 1; Class 20C.
- B. Material and Finish of Tray, Fittings, and Accessories: Steel, hot-dipped galvanized after fabrication.
- C. Inside dimensions as required per NEC for number of conductors indicated.
- D. Inside Radii of Fittings: 24 inches or as indicated.
- E. Accessories and Fittings: Manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
- F. Covers: Solid, flush cover.

PART III - EXECUTION**3.01 INSTALLATION**

- A. Installation: In conformance with NEMA VE 1 requirements and in accordance with manufacturer's instructions.
- B. Support cable tray at each connection point, at the end of each run, and at other points to maintain spacing between supports of 8'-0" maximum.
- C. Use expansion connectors where indicated in NEMA VE 1.
- D. Cut standard straight sections to length in field.
- E. Provide bonding continuity between cable tray sections and fittings in accordance with manufacturer's instructions. Make connections to aluminum tray and fittings using an anti-oxidant compound.

END OF SECTION 16114

PART 1 – GENERAL**1.01 DESCRIPTION**

- A. Scope: Electrical contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install underground duct banks.
- B. Coordination: Duct bank routing on the Drawings is diagrammatic. Coordinate installation with piping and other underground systems and structures and locate clear of interferences.
- C. Related Sections:
 - 1. Section 02220: Excavation and Backfill.
 - 2. Section 03200: Concrete Reinforcement.
 - 3. Section 03300: Cast-In-Place Concrete.
 - 4. Section 16117: Manholes.

1.02 QUALITY ASSURANCE

- A. Reference Standards: Comply with applicable provisions and recommendations of the National Electrical Code and National Electrical Safety Code.

1.03 SUBMITTALS

- A. Shop Drawings: Submit for approval the following:
 - 1. Layouts showing the proposed routing of duct banks and the locations of manholes and areas of reinforcement.
 - 2. Profiles of duct banks showing crossings with piping and other underground systems.
 - 3. Typical cross sections.
 - 4. Installation procedures include manhole and handhole details where applicable. Information on manufacturer's data for precast elements of the system.
- B. Record Drawings: Include the actual routing of underground duct runs on record drawings.

PART II - PRODUCTS**2.01 MATERIALS**

- A. Duct: Schedule 40 PVC conduit and fittings as manufactured by Carlon Electrical Products, Amoco Chemicals or equal. Conduit shall not be smaller than 4" in diameter.
- B. Backfill: Select backfill in accordance with Section 02220.
- C. Reinforcement: In accordance with Section 03200 and as shown on the Drawings.
- D. Concrete: Minimum 3000 psi compressive strength in accordance with Section 03300.

PART III - EXECUTION3.01 INSTALLATION

- A. Provide excavation and backfilling required for ductbank installation in accordance with Section 02220.
- B. Make duct bank installations and penetrations through manhole and foundation walls watertight.
- C. Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 3-inch minimum concrete separation between the outer surfaces of the ducts. Stagger conduit joints by rows and layers. Provide side forms for each duct bank.
- D. Provide concrete covering on both sides top and bottom of concrete envelopes around conduits. Concrete covering size shall be as shown on the Drawings. Add red dye to concrete used for envelopes or trowel a coloring on the concrete for easy identification during subsequent excavation.
- E. Firmly fix ducts in place during pouring of concrete. Carefully spade and vibrate the concrete to insure filling of all spaces between ducts.
- F. Make bends with sweeps of not less than 48-inch radius or 5 degree angle couplings. PVC conduit shall not be used within five feet (5) from the building.
- G. Make a transition from non-metallic to rigid galvanized steel conduit where duct banks enter buildings, manholes and outdoor pads. Provide expansion/deflection fittings where required. Terminate ducts in end bells or insulated bushings. Continue ducts inside buildings with rigid steel conduit. Terminations and/or extensions of PVC conduit within or below building shall be made of rigid galvanized heavy-walled steel conduit.
- H. Provide reinforcement for all duct banks in accordance with details shown on the Drawings.
- I. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material or other materials that can damage or contribute to corrosion of ducts or cables or prevent adequate compaction of fill.
- J. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3 inches per 100 feet.
- K. Install a bare stranded #4/0 copper duct bank ground cable in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground cable to building and station ground grid or to equipment ground buses. In addition, connect ground cable to manhole ground rods and to steel conduit extensions of the underground duct system. Provide ground clamp and bonding of each steel conduit extension, where necessary to maintain continuity of the ground system. Terminate ground cable at last manhole or handhole for outlying structures. Grounding conductor shall be carried with the phase conductors.
- L. Where duct banks are installed under grass plots, remove the sod, store at one side and keep watered. As soon as trench is backfilled, replace the sod. Where conduit is installed between trees, protect the trees and roots from damage.
- M. Where duct banks are installed under pavement, replace pavement to match existing conditions.
- N. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a diameter approximately ¼ inch less than the diameter of the duct, through each duct. Then pull

- a brush with stiff bristles followed by a rag swab or sponge through to make certain that no particles of earth, sand or gravel have been left in the duct.
- O. Install a warning ribbon approximately 18 inches below finished grade over underground duct banks. The identifying ribbon shall be a metallic tape, overlain by PVC tape, 6-inches wide, yellow color, permanently imprinted with "CAUTION: BURIED ELECTRIC LINE BELOW" in black letters.
- P. Plug and seal empty spare ducts entering buildings and structures. Seal ducts in use entering buildings and structures with 0-Z/Gedney Type DUX duct sealing compound or equal. Seal shall be watertight.
- Q. Reused Existing Ducts:
1. Pull rag swab through duct to remove water and to clean duct prior to installing new cable.
 2. Repeat swabbing until all foreign material is removed.
 3. Pull mandrel through duct, if necessary, to remove obstructions.
- R. Install duct banks in conformance with National Electrical Code and National Electrical Safety Code.
- S. Duct line shall be at least 30" from the top of the concrete envelope to the finished grade or paving. Change in direction exceeding a total of 10 degrees (either vertically or horizontally) shall be accomplished by the use of manufactured bends.

END OF SECTION 16116

PART I – GENERAL1.01 DESCRIPTION

- A. Scope: Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install manholes.
- B. Coordination: Coordinate manhole installation with piping, sheeting and other underground systems and structures and locate clear of interferences.
- C. Related Sections:
 - 1. Section 02220, Excavation and Backfill.
 - 2. Section 16116, Underground Duct Banks.

1.02 QUALITY ASSURANCE

- A. Reference Standards: Comply with applicable provisions and recommendations of the following except where otherwise shown or specified:
 - 1. National Electrical Code (NEC).
 - 2. National Electrical Safety Code (NESC).
 - 3. American Society of Testing Materials (ASTM).
 - 4. Construction Materials Testing Institute (CMTI).

1.03 SUBMITTALS

- A. Shop Drawings: Submit for approval the following:
 - 1. Manufacturer's technical information for manholes and accessories proposed for use.
 - 2. Drawings showing interior and exterior dimensions and details of openings, jointing, inserts, reinforcing and waterproofing.
 - 3. Calculations by a State-registered structural engineer to confirm H-20 bridge loading.

PART II - PRODUCTS2.01 MATERIALS

- A. Material and Construction:
 - 1. Precast type of reinforced concrete.
 - 2. Minimum interior dimensions as indicated on the Drawings.
 - 3. Manufacture under controlled conditions, using steel forms. Do not subject to the elements or to internal or external vibration of concrete. Conduct periodic testing and control in accordance with the Construction Materials Testing Institute (CMTI).
 - 4. Concrete shall be produced on a performance basis using 7 ½ bag mix cement. The strength of the concrete shall be 3500 psi or greater in 28 days or at time of delivery. Design strength shall be determined in conformance with ASTM C94, Section 15, Table I with a coefficient of variation of 15 percent and a required over-design factor of 1.14.
 - 5. Basis for concrete strength shall be the 6 by 12 test cylinder made in conformance with ASTM C 31 and tested in conformance with ASTM C 39. Test cylinders shall be made at the discretion of and by representatives of CMTI.

6. Pouring of the concrete shall be done under controlled conditions with temperature not lower than 50 degrees F or higher than 85 degrees F. Units shall be allowed to cure for 24 hours before removal to drying yards.
7. Steel reinforcing shall be H-20 bridge loading using new billet steel welded into cages and installed in steel forms before pouring of concrete.
8. Bottom of manhole shall be precast concrete and shall include an 18-inch by 18-inch by 4 1/2-inch deep sump for water removal and a preformed hole for insertion of a 3/4-inch diameter ground rod.
9. Install inserts for lifting lugs and cable racks.
10. Manholes shall include an anti-flotation ring where indicated on the Drawings.
11. Provide exposed grounding lugs on the interior of the manhole that are connected to the reinforcing steel of the manhole. Grounding lugs shall be provided on the interior corners of the manhole and the center of each manhole wall for a total of 8 grounding lugs per manhole interior. Grounding lugs shall be provided at 6'-0" above the manhole floor. Grounding lugs will be used to create an interior grounding loop in the manhole.
12. Product and Manufacturers: Provide manholes by one of the following:
 - a. A.C. Miller
 - b. PennCast
 - c. Or equal

B. Accessories:

1. Frames:
 - a. Material: Cast iron conforming to ASTM A 48, Class 30A.
 - b. Frame shall be grouted on the manhole.
 - c. Manufacturer: Provide frames of one of the following:
 - 1) Neenah Foundry Company
 - 2) Campbell Foundry Company.
 - 3) Or equal
1. Covers:
 - a. Material: Cast aluminum.
 - b. Size: 33-inches in diameter.
 - c. Type: Watertight, sealed and marked "ELECTRICAL" in four inch high letters.
 - d. Number: One or two as shown on Drawings.
3. Pulling Irons:
 - a. Material: 7/8-inch diameter formed galvanized steel.
 - b. Finish: Hot dipped galvanized.
 - c. Number: Minimum of two cast in the wall opposite the centerline of incoming duct banks.
 - d. Product and Manufacturer: Provide one of the following:
 - 1) Cat. No. 8119 by A.B. Chance Company.
 - 2) Or equal.
4. Cable Racks:
 - a. Material: Hot rolled carbon steel channel.
 - b. Finish: Hot dipped galvanized.
 - c. Rack inserts shall be provided on each wall at intervals not to exceed 36-inches horizontally and 30-inches vertically.
 - d. Product and Manufacturer: Provide one of the following:
 - 1) Cat. No. J-5128 by Joslyn Manufacturing Company.
 - 2) Or equal.
5. Cable Hooks:
 - a. Material: 3/16-inch hot rolled steel.
 - b. Finish: Hot dipped galvanized.
 - c. Product and Manufacturer: Provide one of the following:
 - 3) Cat. No. J-5133A or J513A by Joslyn Manufacturing Company.
 - 4) Or equal.

6. Insulators:
 - a. Material: Porcelain.
 - b. Product and Manufacturer: Provide one of the following:
 - 1) Cat. No. J-5122 by Joslyn Manufacturing Company.
 - 2) Or equal.
7. Ground Rods:
 - a. Material: Copperclad rigid steel rods, $\frac{3}{4}$ -inch diameter, 10 feet long.
 - b. Manufacturer: Provide ground rods by one of the following:
 - 1) Copperweld, Bimetallics Division
 - 2) ITT Blackbury Company.
 - 3) Or equal.

PART III - EXECUTION

3.01 INSTALLATION

- A. Install manholes where shown on Drawings. Verify final locations in field. Provide excavation and backfilling required for installation.
- B. Complete installation of manholes so that structures are watertight. Prime and seal all joints. Apply foam sealant to all penetrations and apply two coats of heavy-duty coal tar pitch waterproofing compound to all exterior surfaces.
- C. Cable Supports in Manholes:
 1. Attach cable racks with B-Line hardware as shown on the Drawings.
 2. Provide cable hooks to support each cable on each rack along the cable run within the manholes.
 3. Individually support each cable at each hook on porcelain insulators. Provide sufficient slack for each cable.
 4. Securely tie each cable in place at each insulator block to prevent excessive movement of insulators, cables, or fireproof tape. Tie cables with non-metallic $\frac{3}{4}$ -inch strapping tape as manufactured by 3M or tie down with nylon straps.
- D. Grounding: Install five (5) $\frac{3}{4}$ -inch by 10-foot copper-clad ground rod for each manhole. Install four rods outside of the manhole, one foot from each wall, and one rod through the base of the manhole. Connect the five rods with #4/0 bare copper cable to form a ground loop. Provide interior ground loop at 6' above manhole floor that is connected to the manhole grounding lugs. Bond the manhole reinforcement and all exposed metal manhole accessories including the frame, pulling irons, cable racks and ladder with No. 4 AWG minimum bare copper wire and connect to the interior ground rod and to the duct bank ground cable.
- E. Provide reinforced concrete pipe grading rings for manholes to adjust cover to proper grade. Stacks shall be constructed on the roof slab on which the manhole frame and cover shall be placed. The height of the stack shall be such as is necessary to bring the frame to the proper grade.

- F. Wrap cables located within manholes with fireproofing tape for their entire length on an individual cable basis. Tape shall be 30 mills thick of self-extinguishing material that will not support combustion. Tape shall not deteriorate when subjected to water, salt, sewage or fungus and shall be secured with glass cloth tape. Fireproofing shall conform to the cable manufacturer's recommendations and shall extend at least one inch into ducts.

END OF SECTION 16117

PART I - GENERAL1.01 WORK INCLUDED

- A. Wires and cables.
- B. Wiring connectors and connections.

1.02 RELATED SECTIONS

- A. All provisions of the contract including Project Manual requirements, apply to this Section.

1.03 CODES AND STANDARDS

- A. NFPA 70 - National Electric Code

1.04 SUBMITTALS

- A. Submit product data under provisions of Section 16010.

PART II - PRODUCTS2.01 WIRE AND CABLE (600 V Insulation)

- A. Provide single-conductor, annealed copper wire and cable with insulation rated 600 V of sizes specified and scheduled on drawings and as manufactured by Southwire, Rome, Essex, or approved equal, for secondary service, feeders, branch and system wiring. Wire insulated for 300 V may be used where voltage is less than 100 V, if isolated from higher voltages. Wire sizes shown and specified are American Wire Gauge for copper
- B. Metal clad cable shall be Type MC 600 V copper with full sized insulated ground conductor. Use is restricted by requirements of "Wiring Methods" in Part 3 of this Section. Minimum size shall be #12 AWG unless specified otherwise.
- C. Wire #8 and larger shall be stranded; #10 and smaller shall be stranded. Wire and cable shall have THWN-THHN insulation.
- D. Motor control circuits and signal wiring may be #14 stranded if NEC requirements are met.
- E. Wiring within light fixtures and other high temperature equipment shall have 150° C insulation as required by NEC.
- F. Cable for direct burial shall be UF.
- G. Insulation for General Use Wire and Cable: ANSI/NFPA 70; Type THHN/THWN insulation for alternating current feeders and branch circuits; and type RHH for direct current wiring.
- H. Wire for Use in Cable Tray (Interior Applications): Single conductor, annealed copper, NEC type XHHW rated for 90 degrees C, 600 volts, and shall be tray rated with "TC" imprinted on outer jacket.
- I. Arc-proofing:
 - 1. Provide flexible, flame-retardant, organic-composition-coated elastomer arc-proofing tape on power cable in manholes and handholes, suitable to withstand 200 A arc for 30 seconds. Tape shall be self-extinguishing and shall not support combustion.

2. Apply tape in single, half-lapped layer as required by manufacturer's recommendations. Secure with strips of red plastic film tape on 208Y/120V conductors and yellow plastic film tape on 408Y/277V conductors.
- J. Provide three-ply marlin twine lacing or self-extinguishing nylon straps with -65 to 350° F range for bundling conductors.

2.02 FEEDER IDENTIFICATION

- A. Provide non-ferrous identifying tags or pressure-sensitive labels for cables, feeders, and power circuits in vaults, pull boxes, manholes and switchboard rooms, at cable termination and in other locations.
- B. Tags or labels shall be stamped or printed to correspond with markings on Drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with 1/32" diameter nylon 55-pound test monofilament line or slip-free plastic cable lacing unit.

2.03 COLOR CODING

- A. Color code secondary service, feeders, and branch circuit conductors as follows:

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

- B. Colors shall be factory-applied entire length of conductors by one of the following methods except as noted and limited below:
 1. Solid color compound
 2. Solid color coating
 3. Colored stripping (2 stripes 180 degrees apart)
 4. Colored bands or hash marks with maximum spacing of 18"
 5. Colored fibrous covering, or
 6. Surface printing every 12", maximum spacing of 18".
- C. Branch circuit conductors #12 and #10 shall have solid color compound, solid color coating or colored fibrous covering. Neutrals and equipment grounds shall have solid compound or solid color coating (white, gray, and green), except that neutrals with colored stripe shall be used where required by NEC. Conductors #8 and larger with stripes, bands, or hash marks shall have background color other than white, green, and gray.
- D. Solid color coating, stripes, bands, or hash marks shall be strongly adherent paint or dye, sufficiently wide and clear to be readily distinguishable after installation.
- E. Alternative field-applied color coding methods may be used for wire #10 or larger, with color code specified in Subparagraph A:
 1. Apply 3/4" colored pressure-sensitive plastic tape in half overlapping turns for 6 inches from all terminal points and in boxes in which splices or taps are made. Apply last two laps of tape with no tension. Do not cover cable identification markings.
 2. Identify with nylon, self-extinguishing, self-locking colored cable ties. Ties shall accommodate wire sizes 1/16" through 1-3/4" in diameter and shall be not less than 0.18 inches wide. Minimum

tensile strength shall be at least 50 lbs. Temperature range shall be -65° F to +350° F. Provide three ties to each wire at each terminal point starting 3 inches from terminal and spaced 3 inches apart and three ties to each wire in boxes where splices or taps are made with special tool or pliers and cut off excess.

2.04 CONNECTORS AND LUGS

A. Connectors for splicing copper conductors:

1. Connectors for straight splicing:
 - a. For Conductors 8 AWG and Smaller: Insulated solderless compression type, Burndy "Hylink" or Thomas & Betts "Sta-Kon".
 - b. For Conductors 6 AWG and Larger: Solderless compression two-way type, Burndy Type YS-L or Thomas & Betts 54500 Series.
2. Connectors for Pigtail Splicing Conductors (8 AWG and Smaller): Soldieries type with a metallic insert connector within a plastic insulating cover having a temperature rating of 105 degree C, 600 volts; Buchanan, Ideal, or Scotchlok.
3. Connectors for Three-Way Splicing Conductors (6 AWG and Larger): Solderless compression type, Burndy or Thomas & Betts.

B. Lugs for terminating copper conductors:

1. Power Conductors 8 AWG and Smaller: Solderless type, manufacturer's standard, unless otherwise specified.
2. Power Conductors 6 AWG and Larger: Solderless compression type, with two-hole tongue, Burndy or Thomas & Betts.
3. Control and Switchboard Wiring: Solderless compression type with tinned ring tongue, Burndy "Hylug" or Thomas & Betts "Sta-Kon".

2.05 TERMINAL BLOCKS

A. Terminal Blocks for use in control wiring panels and terminal cabinets: Molded barrier type rated 30 Amps, 600 Volts with washer head binding screws and white marking strip. Acceptable products are:

1. Cutler-Hammer, Bulletin 10987
2. General Electric EB-S
3. Marathon 200 HB Series

PART III - EXECUTION

3.01 EXAMINATION

- ##### A. Verify work of other trades likely to damage wiring system has been completed.

3.02 PREPARATION

- ##### A. Completely and thoroughly swab raceway before installing wire.

3.03 WIRING METHODS

- ##### A. Dry Interior Locations: Use only building wire, type THHN/THWN insulation, as applicable, in raceway.
- ##### B. Wet or Damp Interior, Exterior, and Underground Locations: Use only building wire, type THWN insulation, as applicable, in raceway.

- C. Metal Clad Cable shall be type MC 600 V copper with full-sized insulated ground conductor. Minimum size shall be #12 AWG unless specified otherwise. Do not use metal cable except as approved by local code for lighting and receptacle circuits in suspended ceilings and stud-wall partitions.
- D. Critical control systems such as EPO systems etc. shall utilize building wire in EMT. Flexible conduit is not allowed.

3.04 INSTALLATION

- A. Install products in accordance with manufacturer's instructions. All wiring must be installed in conduit or other acceptable raceway unless indicated otherwise on drawings.
- B. Use solid conductor for feeders and branch circuits 10 AWG and smaller.
- C. Use stranded conductors for control circuits.
- D. Use conductor not smaller than 12 AWG for power and lighting circuits.
- E. Use conductor not smaller than 16 AWG for control circuits.
- F. Use 10 AWG conductors for 20 amp, 120 volt branch circuits longer than 75 feet and for 20 amp, 277 volt branch circuits longer than 200 feet.
- G. Install wire and cable in code conforming conduit or raceway.
- H. Pull all conductors into raceway at same time.
- I. Use wire pulling lubricant approved by cable manufacturer for building wire.
- J. All conductors shall be continuous from origin to termination.
- K. Clean conductor surfaces before installing lugs and connectors.
- L. Splices and Terminations:
 - 1. Make splices in branch circuit wiring with UL-listed, solderless connectors rated 600 V, of sizes and types required by manufacturer's recommendations with temperature ratings equal to those of wires. Splice connectors shall be screw-on. Insulate splices with integral covers or with plastic or rubber friction tape to preserve characteristics of wire and cable insulation.
 - 2. Provide standard bolt-on lugs with hex screws to attach copper wire and cable to panelboards, switchboards, disconnect switches and electrical equipment.
 - 3. Make terminations and splices for conductors #6 and larger with corrosion-resistant, high-conductivity pressure indent, hex screw or bolt-clamp connectors, with or without tongues, designed specifically for intended service. Connectors for cables 250 MCM and larger shall have two clamping elements or compression indents. Terminals for bus connections shall have two bolt holes.
 - 4. Ampacity of splices and connectors shall be equal to those of associated wires and cables.
- M. Lace or clip groups of conductors at distribution centers, panelboards, pull boxes, wireways, control panels and similar conditions.
- N. Install phase and neutral conductors of each branch or feeder circuit in a single conduit, except where paralleling circuits are indicated. Install paralleling circuits of identical make-up and length as the paralleled circuit, and terminate conductors at the same location, mechanically and electrically, at both ends, to ensure equal division of the total current between conductors.

- O. Install conductors in such a manner that the bending radius of any wire or cable is not less than the minimum recommended by ICEA and/or the manufacturer. Do not exceed manufacturer's recommended values for maximum pulling tension applied to any wire or cable.
- P. Connect all power wiring to equipment such that phasing will be A-B-C-N left to right, top to bottom, and front to back, where possible; and permanently identify phasing on the structure or housing adjacent to bus. Phase identification A-B-C is equivalent to transformer phase identification X1-X2-X3 and H1-H2-H3.
- Q. Provide copper grounding conductors and straps as required.

3.05 INTERFACE WITH OTHER PRODUCTS

- A. Identify wire and cable under provisions of Section 16195.
- B. Identify each conductor with its circuit number or other designation indicated on Drawings.

3.06 FIELD QUALITY CONTROL

- A. Inspect wire for physical damage and proper connection.
- B. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
- C. Verify continuity of each branch circuit conductor.

3.07 WIRE AND CABLE COLOR CODING

- A. Color code conductors in accordance with item 2.03 of this Section.

END OF SECTION 16120

PART I - GENERAL1.01 WORK INCLUDED

- A. Pullboxes.
- B. Junction boxes.

PART II - PRODUCTS2.01 MATERIALS

- A. Pullboxes and Junction Boxes: Metal construction, conforming to National Electrical Code, with screw-on or hinged cover.
- B. Flush Mounted Pullboxes: Provide overlapping covers with flush-head cover retaining screws, prime coated.

PART III - EXECUTION3.01 INSTALLATION

- A. Locate pull boxes and junction boxes above removable ceilings or in electrical rooms, utility rooms, or storage areas.

END OF SECTION 16131

PART I - GENERAL1.01 WORK INCLUDED

- A. Outlet Boxes.

1.02 RELATED WORK

- A. Section 16141: Wall Switches
- B. Section 16145: Receptacles
- C. Section 16147: Plate Covers

PART II - PRODUCTS2.01 MATERIALS

- A. Boxes: Hot dip galvanized, 1.25 ounces per square foot or cadmium plated, conform to UL requirements.
- B. Interior Boxes: Pressed sheet steel, blanked for conduit. Provide attached lugs for locating.
- C. For Ceiling: 4" octagonal boxes for receiving three or less ½" conduits.
- D. For Flush Mounting in Walls: Boxes with matching plaster cover for single or two gang outlets. For larger boxes, use solid type of special units. In masonry, use deep boxes.
- E. Surface Mounted: 4" square.
- F. For all equipment branch circuits below the raised floor: Die Cast Rain Tight Construction Box made of Copper-free Aluminum; threaded conduit fittings; Red Dot Dry-tite or equivalent.

PART III - EXECUTION3.01 INSTALLATION

- A. Mount outlet boxes flush in areas other than mechanical rooms, electrical rooms, and above removable ceilings.
- B. Adjust position of outlets in finished masonry walls to suit masonry course lines.
- C. Do not install boxes back-to-back in same wall. Coordinate cutting of masonry walls to achieve neat openings for boxes. Use rotary cutting equipment to cut masonry work for installation of electrical fittings.
- D. Locate boxes in masonry walls so that only a corner need be cut from masonry units.
- E. Do not use sectional or handy boxes unless specifically requested.
For boxes mounted in exterior walls, make sure that there is insulation behind outlet boxes to prevent condensation in boxes.
- F. For below raised floor boxes, use UL approved, liquid tight, threaded EMT, Compression fittings.

END OF SECTION 16134

PART I - GENERAL1.01 WORK INCLUDED

- A. Work of this Section includes the installation of a complete system of supports and anchors including, but not limited to, the following:
1. Conduit, bus duct, and equipment hangers, supports, and associated anchors.
 2. Equipment bases and supports.
 3. Sleeves and seals.
 4. Flashing and sealing equipment and penetrations.

1.02 RELATED WORK

- A. Work related to work of this Section includes all of the applicable General Requirements of Division 1, any Supplementary and/or Special Conditions, and the following listed Sections:
1. Section 16010: General Requirements for Electrical Work
 2. Section 16050: Basic Methods and Materials
 3. Section 16111: Conduit
 4. Section 16114: Cable Tray

1.03 REFERENCES

- A. NFPA 70: National Electric Code

1.04 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 01300.
- B. Indicate hanger and support framing and attachment methods.

PART II - PRODUCTS2.01 CONDUIT HANGERS AND SUPPORTS

- A. Hangers for single conduit up to 6": Galvanized steel, adjustable, clevis, listed by manufacturer for application.
- B. Multiple or Trapeze Hangers: Steel channels with spacers and hanger rods; using Unistrut or approved equal with matching accessories.
- C. Vertical Support: Steel riser clamp.

2.02 HANGER RODS

- A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous thread.

2.03 INSERTS

- A. Inserts: Malleable iron case or galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 SLEEVES

- A. Sleeves for Conduit through Non-fire Rated Floors: Form with 18 gauge galvanized steel.
- B. Sleeves for Conduit through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with galvanized steel pipe.
- C. Sleeves for Conduit through Fire Rated and fire Resistive Floors and Walls, and Fireproofing: Prefabricated Fire rated sleeves including seals, UL listed.
- D. Fire Stopping Insulation: Refer to Section 07270.

2.05 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported conduit.

2.06 FINISH

- A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART III - EXECUTION**3.01 GENERAL**

- A. Provide seismic support as required by local jurisdictional authority.
- B. Verify building structure is capable of supporting systems. Provide supplement support as required - do not overload structure.

3.02 INSERTS

- A. Provide inserts for placement in concrete formwork.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying conduit over 4".
- D. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- E. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut flush with top of slab.

3.03 CONDUIT HANGERS AND SUPPORTS

A. Support horizontal piping as follows:

<u>PIPE SIZE</u>	<u>MAXIMUM HANGER SPACING</u>	<u>HANGER DIAMETER</u>
½ thru 1¼"	6'- 6"	3/8"
1½ and 2"	10' -0"	3/8"
2½ and 3"	10' -0"	1/2"
4 and over	10'- 0"	5/8"

- B. Install hangers to provide minimum ½" space between finished covering and adjacent work.
- C. Place a hanger within 12" of each horizontal elbow.
- D. Use hanger with 1½" minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical conduit at every floor.
- G. Where several conduit can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser conduit independently of connected horizontal piping.

3.04 EQUIPMENT BASES AND SUPPORTS

- A. Provide equipment bases of concrete with chamfered edges. See Division 3 for concrete requirements.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment. Anchor all equipment in accordance with code regulations for seismic zone of the project location.
- C. Construct supports of structural steel members. Brace and fasten with flanges bolted to structure.
- D. Provide rigid anchors for conduit.

3.05 FLASHING

- A. Provide flexible flashing and metal counter-flashing where systems penetrate weather or waterproofed walls, floors, and roofs.

3.06 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Extend sleeves through floors 2" above finished floor level. Caulk sleeves full depth and provide floor plate.
- C. Where conduit, bus duct, or cable tray penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with fire stopping insulation and caulk seal airtight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

END OF SECTION 16140

PART I - GENERAL1.01 WORK INCLUDED

- A. Wall Switches.

1.02 RELATED WORK

- A. Section 16134: Outlet Boxes

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are as follows:

- 1. Hubbell 1221 or equal as manufactured by Bryant, Arrow Hart or Leviton.

2.02 MATERIALS

- A. 120/277 Volt AC Switches: Quiet slow make, slow break design, toggle handle, single pole, with totally enclosed case, rated 20 ampere. Provide matching 3 way and/or 4 way switches.

PART III - EXECUTION3.01 INSTALLATION

- A. Mount switches 48" above floor.
- B. Coordinate switch-mounting location with architectural detail.

END OF SECTION 16141

PART I - GENERAL1.01 WORK INCLUDED

- A. Receptacles.

1.02 RELATED WORK

- A. Section 16134: Outlet Boxes
- B. Section 16147: Plate Covers
- C. Section 16161: Grounding

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers for general purpose wall mounted, self grounding receptacles are as follows:
Hubbell #5252 or equal as manufactured by Bryant, Arrow Hart, or Leviton.

2.02 DEVICES

- A. Standard Duplex Receptacles: Full gang size, polarized, duplex, parallel blade, U-grounding slot, specification grade, rated at 15 amperes, 125 volts, designed for split feed service.
- B. Nameplates: Provide engraved or embossed plastic for receptacles other than standard duplex receptacles indicating voltage, phase, and amperes.

PART III - EXECUTION3.01 INSTALLATION

- A. Mount general-purpose receptacles vertically at 18" above finished floor, with grounding pole at top.

END OF SECTION 16145

PART I - GENERAL1.01 WORK INCLUDED

- A. Plate Covers

1.02 RELATED WORK

- A. Section 16141: Wall Switches
- B. Section 16145: Receptacles

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers for stainless steel, general purpose plate covers are as follows:
 - 1. Bryant
 - 2. Hubbell
 - 3. Mulberry

2.02 MATERIALS

- A. Stainless Steel: Type 302/304, 0.04" thick, accurately die cut, protected with release paper.
- B. Gaskets: Resilient rubber or closed cell foam urethane.

2.03 PLATES

- A. Flush Mounting Plates: Smooth finish and contoured edges, stainless steel.
- B. Surface Box Plates: Raised stamped, steel, pressure formed for smooth edge to fit box.
- C. Where two-gang boxes are required for single-gang devices, provide special plates with device opening in one gang and second gang blank.

PART III - EXECUTION3.01 INSTALLATION

- A. Install coverplates on all wiring devices.

END OF SECTION 16147

PART I - GENERAL1.01 WORK INCLUDED

- A. Lighting, Receptacle, and Power Panelboards.

1.02 REQUIREMENTS

- A. Construct panelboards to UL standards and provide UL labels.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers for 3 phase, 4 wire, 480/277 volt, 3 phase, 3 wire, 480 volt, and 3 phase, 4 wire, 208/120 volt, 60 Hz panelboards are as follows:
 - 1. Square D
 - 2. General Electric
 - 3. Eaton- Cutler Hammer
 - 4. Siemens

2.02 CONSTRUCTION

- A. Panelboards: Panelboards shall be dead front with front accessibility only. The framework is to be code gauge steel rigidly welded and bolted together to support the cover and installation. Ventilating louvers shall be provided when required. The panelboards will have adequate lifting means and be capable of being rolled or moved into its installation position. Exterior and interior metal surfaces of the panelboards shall be finished with acrylic baked enamel over an iron phosphate pre-treatment. The enamel finish shall be medium light gray, ANSI #49.
- B. The panelboards bussing is to be plated copper and of sufficient cross-sectional area to meet Underwriters' Laboratories Standard #891 on temperature rise.
- C. The circuit breaker distribution panel bussing shall be bus bar design supplied with an Underwriters' Laboratories short circuit current rating, as indicated on the electrical drawings.
- D. Group-mounted branch circuit breakers are to be totally front accessible and front connectable. The circuit breaker's connections to the distribution panel bussing shall be of a "bolt-on" design such that the connections grip the bus bars firmly under heavy fault current conditions. The branch circuit breakers shall be removed by unbolting them from the bus after the disconnection of the load side cable terminations.
- E. All Distribution (DP), Power (PP) and Receptacle (RP) panels shall be furnished with uninsulated copper ground bus, drilled and tapped for a minimum of six (6) 1/4-20 ground screws, complete with screws.
- F. Panelboards shall be surface-mounted, complete with panel trim and concealed hinges and trim mounting screws. Provide locking door with flush catch.
- G. Keys: Provide two keys for each panel. Make keys interchangeable for panels of same voltage.
- H. Double Hinged doors must be provided for all panels. Circuit breaker handles must not be exposed.

PART III - EXECUTION3.01 INSTALLATION

- A. Panelboards shall be installed surface mounted on walls where indicated on the drawings. Provide skirts and cap from panelboard to floor and/or ceiling to conceal conduit and wiring. Cap and skirt shall match panelboard in width, depth, and finish.
- B. Panelboards shall be mounted with top circuit breaker handle not more than 6'-6" above finished floor.
- C. Conductors within panels shall be grouped and laced with nylon tie straps. Only one conductor shall be installed under terminal of individual circuit breaker.
- D. Each circuit protective device shall be identified with numeral designation, cross-referenced with typewritten circuit directory on interior of panel door. Multi-section panels shall be consecutively numbered; it is not acceptable to restart numbering each section of multi-section panels with the number one (1).
- E. Where multi-section panelboards are required, all sections shall have fully rated bus and shall be interconnected by copper conductor with total ampacity equal to main bus rating. Aluminum conductors will not be acceptable.
- F. A copy of each panel directory, reflecting all field changes, shall be included in the bound data to be provided by the Contractor at time of final inspection.
- G. Provide all night light, fire alarm panel, or associated 120 Volt power, emergency (battery pack) light, and elevator cab light circuit breakers with handle lock-offs.
- H. Panelboard cans of multi-section panelboards shall be of the same dimensions.
- I. Prepare and affix typewritten directory to inside cover of panel board, indicating loads controlled by each circuit. MANDATORY

3.02 SHORT CIRCUIT RATING

- A. Fusible panelboards shall be UL listed and labeled for use on a system capable of delivering not more than the true RMS symmetrical amps as indicated on the drawings.
- B. Circuit breaker panelboards shall be fully rated or series rated with its upstream overcurrent device for the available fault current scheduled on the drawings.

END OF SECTION 16160

PART I - GENERAL1.01 WORK INCLUDED

- A. The building electrical system shall be a grounded wye supplemented with equipment grounding systems. All panelboard cabinets, equipment and enclosures, and complete conduit system shall be grounded securely to provide a low impedance path for potential ground faults.
- B. All work under this Section of the Specifications shall be in accordance with Article 250 of the National Electrical Code.

PART II - PRODUCTS2.01 GROUNDING

- A. All grounding conductors shall be copper. All conductors shall be stranded. Ground conductors shall be bare copper or type THHN with green insulation.
- B. Aluminum grounding conductors will not be acceptable.
- C. Equipment grounding conductors for branch circuits shall be sized in accordance with table in article 250 of the NEC.
- D. Grounding electrode conductors shall be sized in accordance with table in article 250 of the NEC.

2.02 CONNECTIONS

- A. Grounding conductors terminating on grounding bus of electrical equipment shall be terminated with lug furnished with equipment.
- B. Grounding conductor termination on water pipe shall be made with UL listed grounding clamp.
- C. Grounding conductor termination on building steel shall be thermowelded.

PART III - EXECUTION3.01 INSTALLATION

- A. The neutral of all dry type transformers shall be grounded to building steel or cold water pipe. Connection to building steel shall be made in a location in unfinished space where the connection will not be subject to physical abuse.
- B. All electrically operated equipment shall be bonded to the ground conduit system.
- C. All ground connections shall have clean contact surfaces.
- D. Install all grounding conductors in conduit and make connections readily accessible for inspection.
- E. Raised computer room floor shall be grounded to stringers, building steel, electrical equipment and incoming cooling piping as indicated on drawing details and plan drawings.

3.02 SIGNAL REFERENCE GROUND GRID (SRG) TESTING

- A. The Computer Room/Data Center grounding system, below raised floor, shall be tested using a Fluke or equal digital multi-meter and a Biddle null-megger or equal instrument.
- B. The following measurements shall be recorded and test results forwarded to the owner's field representative for the owner's records:
 - 1. AC current measurements on at least two grounding and four bonding conductors for the SRG. The AC current on any portion of the SRG shall be less than 250 Ma. If greater, notify owner's field representative for direction.
 - 2. Impedance measurements of the equipment grounding conductors on AC branch circuits and equipment enclosures (minimum five from each PDU/CPC - coordinated with owner's field representative for additional measurement requirements, if any). The impedance of any equipment grounding conductor shall be less than 0.1 OHM. If greater, notify owner's field representative for direction.
 - 3. Resistance measurements between the building grounding electrodes and the SRG (minimum two tie-in points - coordinated with owner's field representative for additional measurement requirements, if any). Measurements shall be made using an earthground tester in a two point configuration. Resistance shall be less than 0.1 OHM. If greater, notify owner's field representative for direction.

END OF SECTION 16161

PART I - GENERAL**1.01 WORK INCLUDED**

- A. All grounding electrodes and conductors and devices, as indicated on the drawings, to provide a low impedance path for potential ground faults.
- B. All work under this Section of the Specifications shall be in accordance with Article 250 of the National Electrical Code.

1.02 SYSTEM DESCRIPTION

- A. Perform all work required to establish and maintain continuity of neutral and equipment grounding systems in conformity with ANSI/NFPA 70 and applicable specific requirements including:
 - 1. ANSI/IEEE 32 – Requirements, Terms and Test Procedures for Neutral Grounding Devices.
 - 2. ANSI/IEEE C2 – National Electrical Safety Code.
 - 3. ANSI/IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
- B. Bond together building steel, ground electrodes, and metal underground water pipe.
- C. Where and as indicated on the drawings, provide grounding interconnections consisting of non-insulated cable, installed in PVC raceway where required.

1.03 REFERENCES

- A. Materials and workmanship shall conform to the latest issue of all industry standards, publications, or regulations referenced in Division 16 and with the following references as applicable.
 - 1. ANSI-NFPA 70 - National Electrical Code.

1.04 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.05 GROUNDING ELECTRODE SYSTEM

- A. Existing metal underground water pipe.
- B. Metal frame of the building.
- C. Ground grid.
- D. Rod electrodes and test wells as indicated.

1.06 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Product Data: Provide data for grounding electrodes and connections.
- C. Manufacturer's Instructions: Include instructions for storage, handling, protection, examination, preparation, and installation of exothermic connectors.

1.07 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 16010.
- B. Accurately record actual locations of grounding electrodes and test wells.

PART II - PRODUCTS**2.01 ROD ELECTRODES**

- A. Material: Copper-clad steel.
- B. Diameter: 3/4 inch.
- C. Length: 10 feet.

2.02 WIRE

- A. Material: Stranded copper. Where indicated, provide insulated wiring conforming to Section 16120 requirements and provisions of this Section.
- B. Grounding Electrode Conductor: As shown on the Drawings and specified by this Section.

2.03 RACEWAYS

- A. Provide raceways for installation of grounding system conductors as indicated on the drawings or as otherwise required.

2.04 GROUNDING

- A. All grounding conductors shall be copper.
- B. Aluminum grounding conductors will not be acceptable.
- C. Grounding electrode conductors shall be sized in accordance with table 250-94 of the NEC.

2.05 CONNECTIONS

- A. Grounding conductors terminating on future ground bus of electrical equipment shall be coiled for future connection.
- B. Grounding conductor termination on water pipe shall be made with UL listed grounding clamp.
- C. Grounding conductor termination on building steel shall be thermowelded.

PART III - EXECUTION**3.01 EXAMINATION**

- A. Verify that final backfill and compaction have been completed before driving rod electrodes.
- B. Examine areas and conditions, state of existing grounding, and adjoining construction under which electrical grounding and bonding connections are to be made and notify the Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.

3.02 INSTALLATION

- A. Provide and install all grounding conductors, ground rods, connectors, miscellaneous equipment, and connections as shown on drawings.
- B. Grounding electrodes shall be placed where indicated on the drawings. Spacing between electrodes shall be equal to or greater than the length of the electrodes. Install additional ground rods as required to achieve ground resistance of 25 ohms.
- C. Buried connections shall be made by an exothermic welding process. Molds used for the welding process shall be new having no prior usage. Molds shall be the specific type for the connection to be made.
- D. Contractor shall install PVC conduit where indicated on drawings and where physical protection is required. Nylon bolts and nuts shall be used on all PVC mounting brackets to avoid metal encirclement of grounding conductors.
- E. Install grounding well pipe with cover at locations indicated. Install well top flush with finish grade.
- F. Ground rods shall be driven vertically into the ground until the top of the rod is below the frost line.
- G. All connections to buried ground system shall take place at a ground rod, not along a point on the conductor system. All bends greater than 90 degree shall be made with radius of more than 12 inches.
- H. Provide grounding electrode conductor and connection to reinforcing steel at base of all columns and at perimeter footings 30'-0" o.c.
- I. All ground connections shall have clean contact surfaces.
- J. Refer to grounding details on drawings for additional information.

3.03 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
- B. Use suitable test instrument to measure resistance to ground of system. Perform testing in accordance with instrument manufacturer's requirements using fall of potential method.

END OF SECTION 16162

PART I - GENERAL1.01 SECTION INCLUDES

- A. Fusible switches.
- B. Non fusible switches.

1.02 REFERENCES

- A. All disconnect switches shall be manufactured in accordance with NEMA standards, shall conform to NEC requirements and shall bear the UL label.
- B. Materials and workmanship shall conform to the latest issue of all industry standards, publications. Or regulations referenced in this section and with the following references as applicable. Refer to Section 16010 for listing of issuing organizations or agencies.
 - 1. NECA - Standard of Installation (published by the National electrical Contractors Association).
 - 2. NEMA FU1 - Low Voltage Cartridge Fuses.
 - 3. NEMA KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 - 4. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (published by the International Electrical Testing Association).
 - 5. NFPA 70 - National Electrical Code

1.03 SUBMITTALS FOR REVIEW

- A. Submit shop drawings and product data under provisions of Section 01300.
- B. Section 16010: Procedures for Submittals
- C. Product Data: Provide switch ratings and enclosure dimensions.

1.04 SUBMITTALS FOR CLOSEOUT

- A. Record actual locations of enclosed switches in project record documents.

1.05 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART II - PRODUCTS2.01 MANUFACTURERS

- A. Eaton- Cutler Hammer
- B. General Electric
- C. Square D
- D. Siemens

2.02 MATERIALS AND EQUIPMENT

- A. All disconnect switches shall be heavy duty type, quick make, quick break, fusible or non fusible as called for, with defeatable door lock interlock which prevents the door from opening when the switch is "on" and all shall have provision for padlocking in the "off" position. Fusible switches shall have rejection type fuse clips.
- B. Switches shall be of sizes and voltage as called for on the drawings.
- C. Disconnect switches shall be in NEMA-3R enclosure where mounted outdoors and in NEMA-1 enclosure where mounted indoors.
- D. All fuses called for on the drawings shall be furnished and installed by the Subcontractor. Fuses shall be of the sizes shown on the drawings and shall be similar to Bussman "Low Peak" current limiting dual element type of motor circuits and similar to Bussman "Limitron" for non-motor circuits.

PART III - EXECUTION

3.01 INSTALLATION

- A. Install and connect all disconnect switches called for on the drawing, or not shown on the drawings but required by the NEC or authorities having jurisdiction and which are not indicated as being furnished by others.
- B. Switches shall be securely attached to surface on which they were mounted. Mount disconnect on wall with unistrut or plywood back panel attached to wall studs. Do not use expansion type sheet rock anchors.
- C. Install in accordance with NECA "Standard of Installation".
- D. Install fuses in fusible disconnect switches.
- E. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.02 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.5

END OF SECTION 16170

PART I - GENERAL1.01 WORK INCLUDED

- A. Electrical connections to equipment specified under other Sections or furnished by Owner.

1.02 RELATED WORK

- A. Section 01010: Summary of Work
- B. Section 15170: Motors
- C. Section 15440: Plumbing Fixtures
- D. Section 15785: Computer Room Air Conditioning Units
- E. Section 15855: Air Handling Units
- F. Section 16000: Electrical Summary of Work
- G. Section 16010: General Requirements for Electrical Work
- H. Section 16111: Conduit
- I. Section 16120: Wires and Cables
- J. Section 16731: Facility Security System

1.03 REFERENCES

- A. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet.
- B. NEMA WD 1 - General Purpose Wiring Devices.
- C. NEMA WD 5 - Specific-Purpose Wiring Devices.

PART II - PRODUCTS

Not Used.

PART III - EXECUTION3.01 INSPECTION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 PREPARATION

- A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.03 INSTALLATION

- A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.
- B. Make conduit connections to equipment using flexible conduit. Use liquid tight flexible conduit in damp or wet locations.
- C. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.
- D. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

END OF SECTION 16180

PART I - GENERAL1.01 WORK INCLUDED

- A. Conduit Supports.

1.02 RELATED WORK

- A. Section 16111: Conduit

PART II - PRODUCTS2.01 CONDUIT SUPPORTS

- A. Single Runs: Galvanized hangers with specialty spring clips. Do not use plumber's perforated straps.
- B. Multiple Runs: Conduit rack with 25% spare capacity.
- C. Vertical Runs: Channel support with conduit fittings.

2.02 ANCHOR METHODS

- A. Hollow Masonry: Toggle bolts or spider type expansion anchors.
- B. Solid Masonry: Lead expansion anchors or preset inserts.
- C. Metal Surfaces: Machine screws, bolts, or welded studs.
- D. Wood Surfaces: Wood screws.
- E. Concrete Surfaces: Self-drilling anchors or power-driven studs.

PART III - EXECUTION3.01 INSTALLATION

- A. Layout to maintain headroom, neat mechanical appearance, and to support equipment loads required.

END OF SECTION 16190

PART I - GENERAL1.01 PROVISIONS

- A. Provide electrical identification when indicated by drawings, schedules, and/or these specifications.
- B. Types of electrical identification specified in this section include the following:
 - 1. Exposed conduit color banding.
 - 2. Cable conductor identification.
 - 3. Operational instructions and warnings.
 - 4. Danger signs.
 - 5. Equipment/System identification signs.

1.02 RELATED WORK

- A. Work related to work of this Section includes all of the applicable General Requirements of Division 1, any Supplementary and/or Special Conditions, and the following listed Sections.
- B. Section 09900: Painting.

1.03 SUBMITTALS

- A. Submit product and manufacturer's installation instructions of Section 01300.
- B. Submit list of wording, symbols, letter size, and color-coding for mechanical identification.

PART II - PRODUCTS2.01 MATERIALS

- A. General
 - 1. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is installer's option, but provide single selection for each application.
- B. Color-Coded Plastic Tape
 - 1. General: Provide manufacturer's standard self-adhesive vinyl tape not less than 3 mils thick by 1-1/2" wide.
- C. Cable/Conductor Identification Bands
 - 1. General: Provide manufacturer's standard vinyl cloth self-adhesive cable/conductor markers of wrap-around type; either pre-numbered plastic self-adhesive cover flap; numbered to show circuit identification.
- D. Plasticized Tags
 - 1. General: Manufacturer's standard pre-painted or partially pre-painted accident-prevention and operational tags, of plasticized card-stock with matte finish suitable for writing, approximately 3 1/4" x 5-5/8", with brass grommets and wire fasteners, and with appropriate pre-painted wording, including large size primary wording (ex: DANGER, CAUTION, DO NOT OPERATE).
- E. Self-Adhesive Plastic Signs

1. General: Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instruction or warnings, of sizes suitable for application areas and adequate for visibility, with proper wording for each application (ex: 208V, EXHAUST FAN, RECTIFIER).
 - a. Colors: Unless otherwise indicated or required by governing regulations, provide orange signs with black lettering.

F. Engraved Plastic-Laminate Signs

1. General: Provide engraving stock melamine plastic laminate in sizes and thicknesses indicated, engraved with engraver's standard letter style of sizes and wording indicated, black with white core (letter color), except as otherwise indicated, punched for mechanical fastening, except where adhesive mounting is necessary because of substrate.
 - a. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.
 - b. Fasteners: Self-tapping, stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.
2. Wherever engraved plates are noted on the drawings, such labels shall be engraved directly into the metal or plastic plate, dead front, or other material.
 - a. Engraved letters shall be 1/4" or 3/8" high, filled with black enamel, and read as directed.

G. Schedules

1. Provide typewritten directory for each panel on heavy card stock, showing all circuit numbers.

2.03 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of marker):
1. W.H. Brady Co.
 2. National Band and Tag Company.
 3. Seton Name Plate Company.
 4. Or approved equal.

2.04 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations, and other designations used in electrical identification work with corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and wording as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment.

PART III - EXECUTION

3.01 INSTALLATION

A. General Installation Requirements:

1. Coordination: Where identification is to be applied to surfaces that require finish, install identification after completion of painting.
2. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

- B. Install engraved plastic laminate nameplates on all switchboards, motor control centers, starters, panelboards, telephone cabinets, disconnect switches, and miscellaneous system junctions boxes and cabinets installed under this contract.
- C. Provide new nameplates for existing equipment (if any) to conform to requirements for new.
- D. Install Bakelite nameplates at each protective device in all switchboards designating circuit service to equipment.
- E. Nameplate Mounting:
 - 1. Switchboards and Motor Control Centers: Mount at top in center of line-up.
 - 2. Panelboards: Mount inside door, on dead front in center, above circuit breakers, unless panelboard is located in a utility-type room, then install nameplate on outside of panelboard in center above door.
 - 3. Disconnect switches, relays, contactors, and time clocks: mount nameplate on outside of cabinet, in center near top.
 - 4. Other: Install nameplate in location as directed.
- F. Install circuit directories in all panelboards affected by this contract.
 - 1. Panelboards: Mount in frame under plastic cover, on backside of door. Schedule shall show circuit service for each circuit breaker using "Owner's" room numbers. Spares and spaces shall be written in pencil.
- G. Apply cable/conductor identification on each cable and conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar field established identification for project electrical work.
- H. Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets, and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.
- I. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to surface with fasteners, except use adhesive where fasteners should not or cannot penetrate the surface.
- J. Warning signs shall be installed at the entrances to rooms and spaces in which electrical systems or equipment is installed.

END OF SECTION 16195

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED****A. General**

1. Furnish outdoor service entrance switchboard, dead front type, completely metal enclosed, self-supporting structure independent of wall supports, front accessible. Voltage rating shall be 480 V, 3 phase, 4 wire, 5000 A, as indicated on the drawings. It shall consist of two vertical sections bolted together to form single rigid switchboard, as indicated.
2. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL891.
3. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL and local utility requirements.
4. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. All control wires shall be marked.
5. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and provided with vendor supplied floor sills to be set level by contractor.
6. Furnish cable pull sections or top cable pull boxes as required. Where cable pull section or pull boxes contain utility service cables, provide utility acceptable sealing means.
7. The enclosure shall be provided with a heater fed from an internal PT.

B. Bussing

1. All bus bars shall be silver-plated copper with bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65° C rise based on UL tests, and rated to withstand mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current of 150 k amperes symmetrical at rated voltages or as shown on the drawings. Provide full capacity neutral where a neutral is indicated on the drawings.
2. A copper ground bus sized a minimum of 50% of switchboard bus rating shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. An incoming ground lug shall be furnished. Other ground lugs for feeder circuits shall also be furnished as shown on the drawings.
3. All hardware used on conductors shall be high-tensile strength and zinc plated. All bus joints shall be provided with Belleville washers.
4. All terminals shall be of the anti-turn solderless compression type suitable for copper or aluminum cable of sized indicated for 75° C cable.
5. The neutral bus shall be connected to the ground bus with a removable disconnect link.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Square D
- B. Westinghouse
- C. GE
- D. Siemens
- E. Russelectric

2.02 SWITCHBOARD TYPE

- A. Service Entrance Switchboard shall have incoming and outgoing cable as well as compression type termination lugs for all feeders.
- B. Switchboard enclosure shall be a NEMA-3R, outdoor type enclosure of front accessible construction.
- C. Construction shall allow maintenance of incoming line terminations, main device connections, and all main bus bolted connections to be performed without rear access. The feeder or branch devices shall be removable from the front and shall be panel mounted with the necessary device line and load connections front accessible. Provide lugs on all devices for cable sizes shown on drawings.
- D. The utility section must meet the requirements and standards of the serving utility.
- E. One outgoing switch section (rated 5000A), shall be furnished with an HPC switch unit and Class "L" fuses.
- F. The service entrance switchboard shall have GFI protection.

2.03 NAMEPLATES

- A. Engraved nameplates shall be furnished for all mains and feeder circuits with designation and circuit number as indicated on the drawings. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.

2.04 ENCLOSURE

- A. Enclosure shall be of NEMA-3R construction, outdoor type, rainproof, non-walk-in, with front accessibility and without rear access. The complete enclosure shall consist of one metering section, one main power input, and two power output sections.

2.05 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 and use the manufacturer's standard process.

END OF SECTION 16425

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED****A. General**

1. Furnish switchgear UPSSA & UPSSB utilizing draw-out insulated case circuit breakers. Voltage rating shall be 480v, 3-phase, 3-wire, 2500a with 100% rated ground bus. It shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on plates. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the roof of the switchboard over the breaker and bus compartments to ensure adequate ventilation within the enclosure.
2. Switchgear shall comply with the latest applicable standards of NEMA SG-5 and UL 1558. The assembly shall bear a UL label. Certified copies of design test reports shall be supplied demonstrating compliance with these standards.
3. The switchgear shall be suitable for use as service entrance equipment and be labeled in accordance with UL and local utility requirements.
4. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, push buttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturers wiring diagrams.
5. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills providing the floor is level 1/8 inch per 3 foot distance in any direction. All necessary hardware to secure the assembly in place shall be provided by the contractor.
6. Adequate bracing shall be provided for setting switchgear over a precast concrete cabling vault. All bottom panels shall be suitable for knockouts, or other means to accommodate cables from vault to breakers.
7. Furnish TVSS as indicated in Section 16670, within each switchgear.
8. All circuit breakers shall be manufactured to UL-1066 and ANSI C37.16.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS****A. Acceptable manufacturers are as follows:**

1. Square D
2. Russelectric
3. General Electric
4. Asco
5. Eaton- Cutler Hammer

2.02 CONSTRUCTION

- A. The switchgear shall be a low voltage, metal enclosed switchgear, utilizing draw-out air circuit breakers as herein specified. The entire assembly shall be suitable for 600 volts maximum AC service.
- B. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment, and a rear cabling compartment. Each individual circuit breaker compartment, or cell, shall be completely segregated from adjacent compartments or sections by means of steel barriers at rear, top, bottom, and sides. It shall be equipped with draw-out rails and primary and secondary disconnecting contacts.

Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells.

- C. The stationary part of the primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit breaker shall include the necessary three phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension busses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.
- D. The secondary disconnecting devices shall consist of floating fingers mounted on the removable unit. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the "connected" and "test" positions.
- E. The removable insulated case circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for draw-out application. It shall have four positions, "connected", "test", "disconnected", and "removed", all of which permit closing the compartment door. The breaker draw-out element shall contain a worm gear leveraging "in" and "out" mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before leveraging "in" or "out" of the cell. The breaker shall include a provision for padlocking open to prevent manual or electrical closing. The padlocking shall also secure the breaker in the connected, test, or disconnected position by preventing leveraging.
- F. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.
- G. Provide a steel shutter that covers the stabs in the cell when the circuit breaker is withdrawn.
- H. Provide a rear compartment steel barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.
- I. Provide all hardware needed to connect the line side and the load side to bus duct copper feeders.
- J. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2,200 volts for one minute between live parts and ground and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1,500 volts for one minute between live parts and ground. A certified test report of all standard production tests shall be available to the engineer upon request.
- K. Rear access to each switchgear section shall be by lockable hinged doors with thermal scan-able sight glass.

2.03 SHORT CIRCUIT RATING

- A. The assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected directly to a power source having available fault current of 100,000 amperes symmetrical at rated voltage.

2.04 BUSSING

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65° C over a 40° C ambient (outside the enclosure).
- B. A copper ground bus sized a minimum of 50% of the switchgear bus rating. shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. An incoming ground lug shall be furnished. Other ground lugs for feeder circuits shall also be furnished as shown on the drawings.
- C. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Bellville washers.
- D. All terminals shall be of the anti-turn solderless compression type suitable for copper cable of the sizes Indicated for 75° C cable.

2.05 METERING

- A. Metering compartment shall contain the following:
 - 1. One ammeter, 0 - 4000 ampere scale, four in. sq.
 - 2. One ammeter switch, four position (three phase and off).
 - 3. One voltmeter, 0 - 600 volt scale, four in. sq.
 - 4. One voltmeter switch, five position for metering (three phase and two off).

Current and potential transformers shall be furnished as required. Transformers shall meet NEMA standard requirements for metering accuracy.

- B. One control power transformer, adequately sized to supply all control power, transformer fan (s), power, and other associated equipment as required.

2.06 CIRCUIT BREAKERS

- A. All feeder circuit breakers shall be three pole, power draw out type, manually operated with stored-energy mechanisms, solid state, long-time and short-time over-current trip devices and integral ground fault protection. All circuit breakers shall have insulated handles, shall be mechanically and electrically "trip-free", and shall have provisions for padlocking in the open position. Breakers shall have external targets to indicate the breaker position. All breakers shall be manufactured to UL-1066 and ANSI C37.16. All circuit breakers shall be rated 100% of their continuous ampere rating. The trip units shall all be as shown on the drawings.
- B. The main and tie circuit breakers shall be similar to the feeder circuit breakers, except they shall have long-time and short-time overcurrent trip devices and integral ground fault protection. Short circuit rating of main, tie, and feeder breakers shall be 100,000 RMS symmetrical amperes.
- C. Where equipped, spaces are required by the contract drawings, they shall be fully equipped to receive future installed circuit breakers of the type indicated.
- D. Circuit breaker shall be furnished with lugs to accommodate 600 volt, single conductor cables, or bus ducts where indicated on the drawings.
- E. Breaker lifting device: Switchgear shall be provided with a manually operated breaker lifting device suitable for serving all breakers.

- F. Breakers shall be manually operated (MO) unless electrically operated (EO) is indicated in the drawings. The breaker control face plate shall include color-coded visual indicators to indicate contact "open" and "closed" positions, as well as mechanism "charged" and "discharged" positions. Manual control push-buttons shall be provided for "opening" and "closing" the breaker.
- G. A selective override circuit shall be provided on breakers having short-time adjustments, but without instantaneous adjustments that will allow selectivity up to its RMS symmetrical short-time rating. This selective override circuit shall allow the breaker to ride through a fully offset (asymmetrical) fault equal to its RMS symmetrical short-time rating in a system having an X/R ratio of 6.6 with a maximum single phase peak current of 2.3 times the RMS symmetrical short-time rating. No deviations from this specification shall be acceptable, unless approved by the engineer in writing.
- H. The breakers shall have high endurance characteristics being capable of no load and full load interruptions at rated current equal to or exceeding the UL endurance ratings for encased breakers without maintenance.

2.07 MICROPROCESSOR BASED TRIP UNIT

- A. Each power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker.
- B. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A trip reset button shall be provided to turn off the LED indication after an automatic trip.
- C. The trip unit shall be provided with a display panel, including a representation of the time/current curve of the trip unit that indicates the protection function settings. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
- D. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with a discriminator or making-current release circuit to prevent closing the circuit breaker on a faulted system. The circuit shall be armed for approximately eight cycles and shall operate for all fault levels above 11 times the ampere value of the rating plug.
- E. The trip unit shall contain an integral test panel with a test selector switch and a test push-button. A potentiometer shall be provided to enable the user to select the values of test currents within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in the "Trip or No Trip" test mode.
- F. The trip unit shall contain a keyed receptacle for use with an optional Auxiliary Power Module. The APM when connected to a 120V, 50/60 Hz source shall provide power for testing the trip unit while the breaker is out of the cell or in the "disconnect" or "withdrawn" position.
- G. A four digit alpha-numeric display shall be provided to indicate the following data:
 - 1. Cause of trip.
 - 2. Instantaneous value of maximum phase and ground current.
 - 3. Approximate level of fault current that initiated an automatic trip operation.

- H. A power/relay module shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, it shall maintain the cause of trip history and the mode of trip LED indication, as long as its internal power supply is available. Internal relays shall provide contacts for remote indication of mode of trip and high load.
- I. A red LED shall be provided on the face of the trip unit pre-set to turn on when 85% of load level is exceeded (a 40 second delay shall be provided to avoid nuisance alarms).

The trip unit shall include a potential transformer module, suitable for operation up to 600 V, 50/60 Hz. The primary of the PTM shall be connected internally to the load side of the circuit breaker through a dielectric disconnect plug. The unit shall calculate energy monitoring parameters as follows:

1. Peak demand (Megawatts).
 2. Present demand (Megawatts).
 3. Energy Consumption (Megawatt-hours).
- J. The trip unit shall be equipped with a product interface card to permit communication via a network twisted pair for remote monitoring and control.
 - K. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit alpha-numeric display panel. The monitoring must be self powered and operational at all times.
 - L. Circuit breaker/trip unit manufacturer shall perform a complete selective coordination study and provide a report showing the time curves and set points of all circuit breaker trip points in the system.
 - M. The electronic trip element and power monitoring must be self powered and operational at all times.

2.08 BUS DUCT AND CABLE TERMINATIONS

- A. Connection to bus duct type terminals shall be provided for all line and load terminations suitable for copper bus duct rated for 75° C of the size as indicated on the drawings.
- B. Compression type lugs shall be provided in the incoming line section and for connection of the main grounding conductor. Additional compression type lugs for connection of other grounding and feeder conductors shall be provided as indicated on the drawings.

2.09 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all mains and feeder circuits, as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16" high, minimum. Nameplates shall give item designation and circuit number, as well as frame ampere size and appropriate trip rating. Furnish Master nameplate giving switchboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number, and item number.

2.10 FINISH

- A. The doors, panels, and sheets shall be finished with the manufacturer's standard gray, semi-gloss paint.
- B. All surfaces shall first be carefully sanded to remove loose scale and abrasions. They shall then be phosphatized to prevent the spreading of rust if the surface is scratched.
- C. Coats of primer and surfacer shall then be applied and shall be carefully rubbed down to assure a smooth finish. The framework, including the vertical and horizontal steel barriers, shall be phosphatized and given one coat of manufacturer's standard gray paint.

PART III - EXECUTION3.01 FACTORY ASSEMBLY AND TEST

- A. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After complete assembly, the unit shall be tested for operation under simulated service conditions by impressing properly phased voltage and current on all components to assure accuracy of wiring, correctness of the control scheme and functioning of the equipment. Dielectric tests of all current carrying parts shall be conducted in accordance with industry standards.
- B. Provide a minimum of fourteen days advance notice of the test, as Owner will be witnessing the test.
- C. Materials and apparatus under these specifications shall be subject to inspection by the purchaser. Purchaser's inspector shall, during working hours, have access to all parts of the shop where material is being manufactured and shall be provided with all reasonable inspection facilities. Release of material shall not relieve manufacturer from contract responsibility nor invalidate any claim which purchaser may make because of unsatisfactory material or construction.
- D. All routine factory tests shall be completed prior to beginning witnessed tests. Witnessed tests shall be in addition to those deemed necessary by the manufacturer and at a minimum shall consist of the following:
 - 1. Alarm and Functional Tests:
 - a. Verify the function and operation of all relays, meters, controls, operator adjustments, lights, alarms, breakers, key interlocking and trip condition.
 - b. An individual test to verify the specified operation of all contacts and signals being supplied to the building management system.
 - 2. Dielectric Test:

Each switchgear will withstand 1500 volts RMS, at 60 Hz frequency, successively applied for one minute between each electric circuit and all other electric circuits with metal parts grounded. Solid state devices may be removed with the circuits during this test. The equipment will not be damaged during tests and will function satisfactorily when installed in the system after completion of the dielectric tests.

3.02 DISASSEMBLY AND SHIPMENT

- A. Upon completion of testing and before crating and shipment, all parts to be disassembled shall be matchmarked to facilitate erection in the field. The substation shall then be disassembled into the required number of parts necessary for shipping. Each part shall be covered with a heavy kraft paper and placed in an individual crate for shipment.

3.03 INSTALLATION

- A. Install switchgear plumb and level where indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products fulfill requirements.
- B. Coordinate switchgear installation work with electrical raceway and cable work, as necessary for proper interface.
- C. Provide connection of conduit, busduct, and other raceways as required.

3.05 SITE ACCEPTANCE TESTS

- A. Field Engineers for Start-Up: After delivery, the seller shall provide one or more qualified, experienced field engineers to assist and supervise start-up commissioning and testing. The Engineer will advise at least ten days in advance of the date when such field engineering support will be required. Such field engineering personnel shall report promptly at the time and place designated by the Engineer and shall be assigned to work continuously until released by the Engineer. Working schedule for these technical representatives will be determined by the Project Engineer.
- B. A complete functional test of the switchgear shall be performed at the site, after installation, to ascertain that:
 - 1. The equipment has suffered no impairment in performance since factory tests were made.
 - 2. The installation is in accordance with these specification requirements.
- C. System test power requirements shall be provided by the Owner's AC service equipment.
- D. The purchaser's personnel will witness the site acceptance test.

3.04 WARRANTY

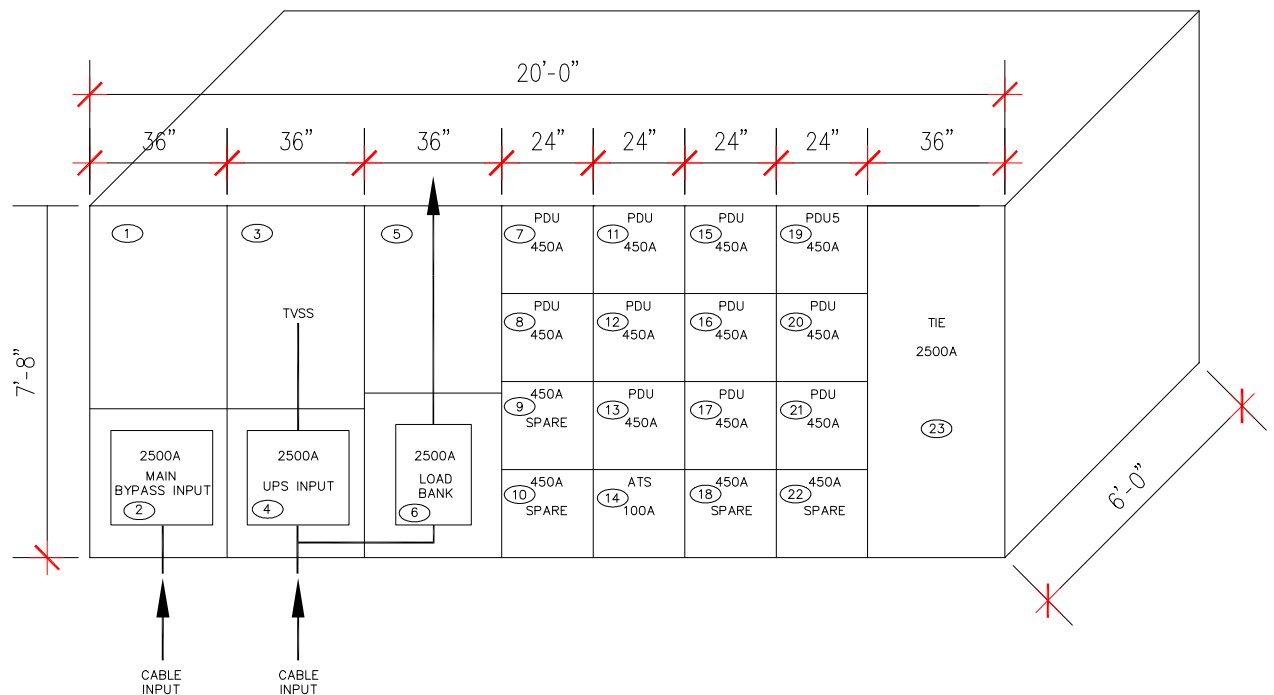
- A. The manufacturer shall warrant the satisfactory and successful operation of all components, material, and structure furnished under these specifications at the rating, under the conditions and for the service specified. The manufacturer further warrants the equipment to be as represented and specified and shall warrant against any and all defects in design, material, and workmanship, and shall, upon written notice by the purchase, remedy such defects as develop under the specified and ordinary use of this apparatus, within five years of actual service, such service to begin after final acceptance by the builder.
- B. The manufacturer's authorized service agent shall provide person-to-person voice communication within one hour of owner's request for service. Manufacturer's agent shall have means of recording all requests for service made via telephone. This shall include electronic time tag. Manufacturer's agent shall further respond to the Owner's site within two hours of the initial call, fully prepared to rectify the situation.

3.06 ALTERNATE QUOTE

- A. Provide an alternate quote for individual remote display in each breaker door indicating:
 - 1. Complete metering:
 - a. RMS Current (each phase)
 - b. RMS Voltage L-L and L-N
 - c. Watts
 - d. VARs
 - e. Volt-Amps
 - f. Power Factor (Total)
 - g. Watt-Hours
 - h. Watt Demand
 - i. Frequency
 - 2. Event Recording:
 - a. Stores up to 50 events
 - b. Events can be breaker trip or meter trip/alarm condition
 - c. Cause of event on screen.
 - d. Visual alarm via New Event LED.

- e. External indication of event via relay contacts.
- f. Event indication enable/disable option
- g. Time of event available at remote personal computer (when using Electrical Distribution Software).

C. Remote indication to a building monitoring system with metering indicated above and event waveform capture of main incoming breaker and main UPS input feed breaker.



2 UPSSA / UPSSB
N.T.S.

END OF SECTION 16427

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED****A. General**

1. Furnish switchgear MSA and MSB comprising of generator paralleling breakers and the closed transition low voltage switchgear with complete integrated controls. Voltage rating shall be as indicated on the drawings. It shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on plates. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure.
2. Switchgear shall comply with the latest applicable standards of NEMA SG-5 and UL 1558. The assembly shall bear a UL label. Certified copies of design test reports shall be supplied demonstrating compliance with these standards.
3. The switchgear shall consist of a line-up of vertical sections bolted together to form a single unitized switchgear. The vertical sections shall be furnished with a minimum of the following operational components and devices:
 - a. All circuit breakers shall be power drawout type with integrally mounted electronic trip units (microprocessor controlled).
 - b. Redundant PLCs which will control the automatic transfer circuit breakers, paralleling breakers, and load bank breaker.
 - c. Feeder breakers as shown on the accompanying single line diagrams.
 - d. CT, PT, metering, relays, terminal blocks, pilot light and switches.
 - e. Best battery scheme for the electrically operated PLC, with third source being a station battery.
 - f. Control power for electrically operated circuit breakers shall be derived from best 7-control transformers at 3- generator inputs, utility input, station battery and 2- tie-breaker inputs.Vendor shall provide all operational components and devices for the future generators A2, B2 and C2 inside the switchgear. The PLC shall be programmed in such a way as to when the program sees the absence of the paralleling generator; it shall revert to the simple program with only one (1) generator.
4. The third input breaker on the generator side of the switchgear shall have the multi-purpose function of temporary generator input, load bank or alternate chiller input. Electronic interlocks will operate through the PLC.
5. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, push-buttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturers wiring diagrams.
6. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position. All necessary hardware to secure the assembly in place shall be provided by the contractor.
7. Adequate bracing shall be provided for setting switchgear over a pre-cast concrete cabling vault. All bottom panels shall be suitable for knockouts, or other means to accommodate cables from vault to breakers.
8. Furnish TVSS as indicated in Section 16670, within each switchgear.
9. The Best battery scheme for the electrically operated PLC shall consist of one source from each generator serving that switchgear with third source being a separate station battery for each system. Batteries shall be mounted in a two tier (No Step) rack with plastic barriers over terminals and battery charger with remote failure indication. The station batteries will be located in each UPS battery room.
10. All protective relays at the Utility breakers must be approved by the local Utility company before fabrication. The relay settings will be determined by the engineer providing the Coordination

Study but the switchgear manufacturer must cooperate with all parties to obtain the necessary Utility approval to operate in a soft loading closed transition mode.

PART II - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturer is as follows:

1. Russelectric
2. GE- Zenith
3. Asco

B. Items specifically called for in this specification are to provide for specific performance and quality of components desired and shall not restrict any manufacturer from furnishing an approved equivalent product for the performance and operation intended as described above.

C. Substitutes must be submitted a minimum of five working days prior to bid date to the Design Engineer for review. The application must contain an itemized estimate for all costs that will result directly or indirectly from acceptance of the substitution, including costs of redesign and claims of other affected contractors. The base bid cost shall be systems and equipment specified. The Contractor, if he proposes a substitution, shall submit within the required time of bid opening a detailed and complete technical proposal with the written request for substitutions and shall include as a minimum of the following items:

1. Written explanation of the function and effect on the operation of the system as specified.
2. Cost differential from that function or component as specified and the amount to deduct from the "as specified" price.
3. The purpose for the requested change.
4. Differences in the weight or dimensions of the "as specified" equipment.

D. Warranty: All equipment detailed herein shall be provided with a guarantee against defects in materials and workmanship for a period of five years after acceptance by the engineer.

2.02 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 01300 AND 01340.

B. As a minimum, the following shall be submitted:

C. Vendor shall provide dimensions and weight of the switch offered in their offer.

D. Final submittals shall include:

- a. Dimensions and weight
- b. Shipping splits
- c. Point-to-point wiring
- d. Elementary and schematic diagrams

E. Site Conditions: All equipment furnished shall be suitable for continuous operation at the following conditions:

- a. Temp Range: 20° F to 120° F
- b. Altitude: 4,670 ft.

- c. Relative Humidity: 0 – 100%

2.03 CONSTRUCTION

- A. The switchgear shall be low voltage and shall use glass reinforced insulating material providing high dielectric strength encased draw-out circuit breakers. The entire assembly shall be suitable for 600 volts maximum AC service.
- B. All draw-out encased circuit breakers shall include microprocessor modules.
- C. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment, and a rear cabling compartment. Each individual circuit breaker compartment, or cell, shall be completely segregated from adjacent compartments or sections by means of steel barriers at rear, top, bottom, and sides. It shall be equipped with draw-out rails and primary and secondary disconnecting contacts. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells.
- D. The stationary part of the primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit breaker shall include the necessary three phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension busses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.
- E. The secondary disconnecting devices shall consist of floating fingers mounted on the removable unit. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the "connected" and "test" positions.
- F. The removable circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for draw-out application. It shall have four positions, "connected", "test", "disconnected", and "removed", all of which permit closing the compartment door. The breaker draw-out element shall contain a worm gear leveraging "in" and "out" mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before leveraging "in" or "out" of the cell. The breaker shall include a provision for padlocking open to prevent manual or electrical closing. The padlocking shall also secure the breaker in the connected, test, or disconnected position by preventing leveraging.
- G. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.
- H. Provide a steel shutter that covers the stabs in the cell when the circuit breaker is withdrawn.
- I. Provide a rear compartment steel barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.
- J. Provide all hardware needed to connect the line side and the load side to bus duct copper feeders, where indicated on the drawings.

- K. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2,200 volts for one minute between live parts and ground and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1,500 volts for one minute between live parts and ground. A certified test report of all standard production tests shall be available to the engineer upon request.
- L. Rear access to each switchgear section shall be by lockable hinged doors with thermal scan-able sight glass.

2.04 SHORT CIRCUIT RATING

- A. The assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected directly to a power source having available fault current of 100,000 minimum amperes symmetrical at rated voltage.

2.05 BUSSING

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65° C over a 40° C ambient (outside the enclosure).
- B. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear.
- C. All hardware used on conductors shall be high-tensile strength, Grade 5 bolts and conical spring Belleville washers. All bus joints shall be provided with Bellville washers.

2.06 METERING

- A. Metering compartment shall contain the following:
 - 1. Electronic meter which will display the following features at minimum:
 - a. Amps ØA, ØB, ØC
 - b. Voltage AB, BC, CA, AN, BN, CN
 - c. KW
 - d. Max Demand
 - e. kVA
 - f. kVAR
 - g. Power Factor
 - 2. Current and potential transformers shall be furnished as required. Transformers shall meet NEMA standard requirements for metering accuracy.

2.07 CIRCUIT BREAKERS

- A. All feeder circuit breakers shall be three pole, power draw out type, solid state, long-time and short time over-current trip devices and integral ground fault protection. All circuit breakers shall have insulated handles, shall be mechanically and electrically "trip-free", and shall have provisions for padlocking in the open position. Breakers shall have external targets to indicate the breaker position. All breakers shall be manufactured to UL-1066 and ANSI C37.16. All circuit breakers shall be rated for 100% of their continuous ampere rating.
- B. The utility source breaker and incoming generator breakers shall be the automatic type controlled by redundant PLCs. Together they will act as a close transition switch for synchronizing with the utility for peaking or load shedding and act as a transfer switch to provide generator back-up power to the

- respective switchgear. Coordination must be maintained between the generator switchgear and the utility source switchgear.
- C. The main and tie circuit breakers shall be similar to the feeder circuit breakers, except they shall have long-time and short-time overcurrent trip devices and integral ground fault protection. Short circuit rating of main, tie, and feeder breakers shall be minimum 100,000 A RMS symmetrical amperes.
 - D. PLC interlocks shall be provided for interlocking the main breakers with the bus tie breaker, and interlocking breakers between this switchgear and loads as noted.
 - E. Where equipped, spaces are required by the contract drawings, they shall be fully equipped to receive future installed circuit breakers of the type indicated.
 - F. Circuit breaker shall be furnished with lugs to accommodate 600 volt, single conductor cables, or bus ducts where indicated on the drawings.
 - G. Breaker lifting device: Switchgear shall be provided with a manually operated breaker lifting device suitable for serving all breakers.
 - H. All draw-out breakers shall be electrically operated (EO) locally or operated through a PLC. The breaker control face plate shall include color-coded visual indicators to indicate contact "open" and "closed" positions, as well as mechanism "charged" and "discharged" positions. Manual control push-buttons shall be provided for "opening" and "closing" the breaker.
 - I. A selective override circuit shall be provided on breakers having short-time adjustments, but without instantaneous adjustments that will allow selectivity up to its RMS symmetrical short-time rating. This selective override circuit shall allow the breaker to ride through a fully offset (asymmetrical) fault equal to its RMS symmetrical short-time rating in a system having an X/R ratio of 6.6 with a maximum single phase peak current of 2.3 times the RMS symmetrical short-time rating. No deviations from this specification shall be acceptable, unless approved by the engineer in writing.
 - J. The breakers shall have high endurance characteristics being capable of no load and full load interruptions at rated current equal to or exceeding the UL endurance ratings for encased breakers without maintenance.
 - K. Each draw out breaker shall have individual remote display in each breaker door indicating:
 - A. Individual remote display in each breaker door indicating:
 - 1. Complete metering:
 - a. RMS Current (each phase).
 - b. RMS Voltage L-L and L-N.
 - c. Watts.
 - d. VARs.
 - e. Volt-Amps.
 - f. Power Factor (Total).
 - g. Watt-Hours.
 - h. Watt Demand.
 - i. Frequency.
 - 2. Event Recording:
 - a. Stores up to 50 events.
 - b. Events can be breaker trip or meter trip/alarm condition.
 - c. Cause of event on screen.
 - d. Visual alarm via New Event LED.
 - e. External indication of event via relay contacts.
 - f. Event indication enable/disable option.

- g. Time of event available at remote personal computer (when using Electrical Distribution Software).
- B. Remote indication to a building monitoring system with metering indicated above and event wave form capture of main incoming breaker and main UPS input feed breaker.
- C. All circuit breakers shall be manufactured to UL-1066 and ANSI C37.16.

2.08 RELAYS

- A. Directional power relays (device #32) (high speed, three phase device) shall be provided at each transformer secondary main switch with appropriately sized current and potential transformers and time delay (device #62).
- B. These directional power relays will be interlocked with the overcurrent relay in the generator switchboard that controls its feeder circuit breaker. This prevents generated power from back feeding into the utility system and also detects ground faults at the primary side of the transformer.
- C. Device #32 shall be capable of detecting reverse current of five milliamperes and trip circuit breaker within five seconds.
- D. Device #47: Phase Sequence Voltage Relay.
- E. Device #81: An under and over frequency relay shall be provided in a single case. The relay operating point shall be settable in 0.05 Hz increments. A built-in time relay shall be included and shall be adjustable in 1 cycle increments up to 99 cycles. Central frequency shall be 60 Hz.
- F. Device 46: A three phase current balance relay with definite time characteristics shall be provided. The trip setting shall be continuously adjustable from 0.3 to 1.2 amps secondary current (120 A to 480 A Pri current). The time setting shall be continuously adjustable from 0.5 to 4 seconds.
- G. Device #59: Overvoltage protective relay.
- H. Electronic multi-function equivalent of these relays may be utilized provided that they are approved by the local Utility Company.

2.09 MICROPROCESSOR BASED TRIP UNIT

- A. All drawout type molded case circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker.
- B. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A trip reset button shall be provided to turn off the LED indication after an automatic trip.
- C. The trip unit shall be provided with a display panel, including a representation of the time/current curve of the trip unit that indicates the protection function settings. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

- D. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with a discriminator or making-current release circuit to prevent closing the circuit breaker on a faulted system. The circuit shall be armed for approximately eight cycles and shall operate for all fault levels above 11 times the ampere value of the rating plug.
- E. The trip unit shall contain an integral test panel with a test selector switch and a test push-button. A potentiometer shall be provided to enable the user to select the values of test currents within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in the "Trip or No Trip" test mode.
- F. The trip unit shall contain a keyed receptacle for use with an optional Auxiliary Power Module. The APM when connected to a 120V, 50/60 Hz source shall provide power for testing the trip unit while the breaker is out of the cell or in the "disconnect" or "withdrawn" position.
- G. A four digit alpha-numeric display shall be provided to indicate the following data:
1. Cause of trip
 2. Instantaneous value of maximum phase and ground current
 3. Approximate level of fault current that initiated an automatic trip operation.
- H. A power/relay module shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, it shall maintain the cause of trip history and the mode of trip LED indication, as long as its internal power supply is available. Internal relays shall provide contacts for remote indication of mode of trip and high load.
- I. A red LED shall be provided on the face of the trip unit pre-set to turn on when 85% of load level is exceeded (a 40 second delay shall be provided to avoid nuisance alarms).
- J. The trip unit shall include a potential transformer module, suitable for operation up to 600 V, 50/60 Hz. The primary of the PTM shall be connected internally to the load side of the circuit breaker through a dielectric disconnect plug. The unit shall calculate energy monitoring parameters as follows:
1. Peak demand (Megawatts)
 2. Present demand (Megawatts)
 3. Energy Consumption (Megawatt-hours)
- K. The trip unit shall be equipped with a product interface card to permit communication via a network twisted pair for remote monitoring and control.
- L. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit alpha-numeric display panel.
- M. Circuit breaker/trip unit manufacturer shall perform a complete selective coordination study and provide a report showing the time curves and set points of all circuit breaker trip points in the system.
- N. In the event the equipment does not perform as heretofore provided, the successful bidder shall at its sole cost, repair or replace the equipment so that it does so perform.

2.10 BUS DUCT AND CABLE TERMINATIONS

- A. Connection to bus duct type terminals shall be provided for all line and load terminations suitable for copper bus duct rated for 75° C of the size as indicated on the drawings.
- B. Lugs shall be provided in the incoming line section for connection of the main grounding conductor and utility service conductors. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

2.11 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all mains and feeder circuits, as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16" high, minimum. Nameplates shall give item designation and circuit number, as well as frame ampere size and appropriate trip rating. Furnish Master nameplate giving switchboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number, and item number.

2.12 FINISH

- A. The doors, panels, and sheets shall be finished with the manufacturer's standard gray, semi-gloss paint.
- B. All surfaces shall first be carefully sanded to remove loose scale and abrasions. They shall then be phosphatized to prevent the spreading of rust if the surface is scratched.
- C. Coats of primer and surfacer shall then be applied and shall be carefully rubbed down to assure a smooth finish. The framework, including the vertical and horizontal steel barriers, shall be phosphatized and given one coat of manufacturer's standard gray paint.

PART III- GENERATOR PARALLELING SWITCHGEAR**3.01 WORK INCLUDED**

- A. The following specifications cover the requirements for providing a complete line-up of freestanding assemblies (generator system switchboard and generator control switchboard) containing circuit breakers, instrumentation, and control devices for emergency system power.
- B. Furnish the generator control and generator system switchgear, arranged to control the operation and distribution of power for the following generating units:

QTY	MOVER	PRIME kW/kVA	STANDBY kW	VOLTS	P.F.	F.L.A.	FREQ.
1+1	DIESEL	*	2000	480	0.8	*	60

*Vendor shall provide this information.

- C. The generator system switchgear shall consist of one complete switchgear line-up. The switchgear line-up shall contain two generator input and closed transition switchgear breakers as shown on single line drawing. All power and control components for the future generator shall be included in the switchgear line-up.
- D. The generator paralleling switchgear shall be 3 phase, 3 wire, with a ground bus sized minimum 50% of switchgear ampere rating.
- E. The switchgear shall be arranged for fully automatic or manual operation at the discretion of the operator. Each Section shall be complete and include the necessary AC instrumentation, relaying, voltage regulator equipment, generator control equipment, engine governor controls, pilot lights, selector switches, etc., and accessories, as shown on the contract drawings and as specified hereinafter.
- F. The generator switchgear line-up, including all internal components mounted, shall be listed and labeled under UL Standard 1558 with a withstand rating of minimum 100,000 amperes symmetrical for four cycles minimum, at the time of the bid opening. Manufacturers submitting equipment line-ups not listed and labeled under UL Standard 1558 without this withstand value shall not be accepted.

- G. All control voltage for auxiliary relays, circuit breakers, synchronizing and other automatic equipment shall be obtained from either the emergency generators or the engine starting batteries.
- H. Any engine generator shall start and assume load within 10 seconds after start circuit is energized, and balance of generators shall then be synchronized, paralleled, and shall divide the load.
- I. Interlocks shall be provided for proper sequencing and safe operation.
- J. The generator system control switchboard shall consist of one complete assembly, capable of controlling two engines and the automatic transfer switch.
- K. A separate station battery shall be included as a third source for the best battery selection system. Battery, battery rack, charger, connectors, and disconnect shall be included.
- L. The two generator switchgear cabinets for the future second generator requirements shall be provided without the circuit breakers, however, the cabinets shall have the provisions to field install the circuit breakers in the future.
- M. Two (2) PLCs are required for each system. Failure of the PLCs shall enable the system to operate manually.
- N. The PLC, with information from the Load Bank switchboard, shall be capable of controlling the third generator input breaker with two Kirk Keyed input functions; temporary third rental generator and Load Bank.

3.02 APPLICABLE STANDARDS

- A. The generator control switchgear covered by these specifications shall be designed, tested and assembled in strict accordance with all applicable standards of ANSI, U.L., IEEE, NEMA and NFPA.

3.03 PRODUCTS

A. Instruments and Sensors

- 1. Ammeters and Voltmeters: Indicating instruments with 4½" square recessed case and 250 degree scale, white dial with black figures, 5 ampere, 60 Hertz movement, one percent accuracy.
- 2. Ammeter and Voltmeter Selector Switch: Rotary multistage snap-action type with 600 volt AC-DC silver-plated contacts, engraved escutcheon plate, pistol-grip, round, knurled, handle, with four positions, including OFF.
- 3. Current Transformers: 5 ampere secondary, wound type, with single secondary winding and primary/ secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.
- 4. Potential Transformers: 120 volt single secondary, with primary and secondary fuse protection, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Generator System Ground Fault

- 1. Manufacturer of this equipment shall coordinate with the manufacturer of the utility main switchgear to assure a properly coordinated and functional ground fault scheme for the facility.

C. Over/Under Voltage and Frequency Relay

- 1. An over/under voltage and frequency relay shall be supplied to monitor the bus voltage and provide alarms and initiate load shedding, if required, for abnormal conditions. Red failure lights, auxiliary contacts, and an alarm in the engine generator master control section will be energized to indicate an abnormal voltage or frequency condition.

D. Automatic DC Control Voltage Sensor System

1. An automatic DC control sensor system shall be provided in the engine generator, master control section to provide DC control voltage. DC control power shall be obtained from any one of the engine starting batteries and the station battery. The sensor shall automatically select the best control voltage from the available batteries. The DC control voltage sensor shall insure a stable system control voltage, as long as any of the battery sources are available.
2. A DC overvoltage protection circuit shall be provided to protect the system from an excessive overvoltage.
3. Station battery system shall be provided and integrated with the DC control voltage system to ensure sufficient DC voltage and current is available to operate all circuit breakers shunt trips and maintain proper power to all PLCs, regardless of the status of the engine starting batteries.

E. Automatic Synchronizer

1. Automatic synchronizers shall be provided, one for each pair of engine generator, with the following features and capabilities:
 - a. All circuitry shall be housed in a rugged semi-dust-tight enclosure, suitable for switchboard mounting. The synchronizer shall contain all control adjustments and input output terminals legibly marked. The inputs shall consist of 120 volt, AC, nominal, 60 Hertz signals from the selected power sources. A separate terminal shall be provided to ground the enclosure.
 - b. The outputs shall consist of the following:
 - i. A bipolar DC signal suitable for driving a governor/amplifier system.
 - ii. A sync contact closure, the purpose of which shall be to operate the selected power circuit breaker when the incoming voltage has the same amplitude, frequency and phase as the main switchboard bus.
 - iii. The synchronizer shall become operative when the incoming voltage source reaches approximately 75% of nominal. It shall assume control to match the frequency and phase of the engine generator with that of the main switchboard bus rapidly, and close the selected power circuit breaker with a minimum of system disturbance. Power circuit breaker closures outside the preset limits shall not occur.
 - iv. Within approximately one second after the power circuit breaker closure, the synchronizer shall automatically relinquish control over the electronic governor and go into an idle mode.
 - v. The synchronizer controls shall consist of the following:
 1. Phase offset control
 2. Gain control
 3. Stability control
 - vi. A separate MODE switch shall be provided for the following modes of operation:
 1. RUN - Normal automatic phase-lock operation control over engine generator voltage, frequency and phase, to provide a sync relay contact closure.
 2. PERM - No control over generator voltage, frequency or phase, but provides a sync relay contact closure when parameters are within the preset limits.
 3. CHECK - Normal automatic phase-lock operation control over engine generator voltage, frequency and phase, but with no sync relay contact closure when sync conditions are met.
 4. OFF - No control over engine generator, voltage, frequency or phase, and no relay contact closure. Engine generator is controlled only by governor and voltage regulator settings.
 - vii. The synchronizers shall operate over an input voltage range of 80% to 125% of nominal, indefinitely, over an ambient temperature range of -45° Celsius to +70° Celsius. The synchronizers shall be capable of meeting the dielectric and surge withstand capabilities, as set forth in IEEE Standard 472-1974/ANSI C37.90a-1974.
 - viii. To insure optimum compatibility with the governor control, the synchronizer shall be by the same manufacturer of the governor control system.

F. Reverse Power Monitors

1. Self-contained, single phase, solid state type reverse power monitors, one for each generator, shall be furnished to detect excessive reverse power flow, caused by the motorizing of a failing generator plant. Upon detection of a true reverse power flow, the monitor shall signal the alarm circuits to immediately disconnect the generator, and to actuate the load shedding circuits. The reverse power monitor shall automatically reset upon generator power disconnect and shall include the following features:
 - a. Time Delay: An adjustable time dial shall be provided with inverse time characteristic.
 - b. Sensitivity: Adjustable taps from 13 to 150 watts.
 - c. Output Relay Contacts: Single pole, normally open contacts rated to close 30 amperes at 250 volts DC. The contacts shall be made of silver with sufficient wipe to insure a positive contact.
 - d. The monitor shall be supplied with a draw-out case. The removable chassis will permit rapid interchanging of similar relay units without requiring panel wiring changes. Chassis units shall be easily removable for test and inspection purposes. Current transformer secondaries shall be automatically short circuited when the relay chassis is removed from the case. The draw-out case will have a dust-tight removable cover.
2. Reverse power protection shall utilize a utility grade relay, with inverse time characteristics. Reverse power relays not having inverse time characteristics or not utility grade, draw-out styles are not acceptable.

G. System Programmable Controller

1. The system will be controlled by a programmable controller. PLC programming for system operation, shall be the responsibility of the switchgear manufacturer.
2. The following shall be provided for the programmable control system:
 - a. One (1) programmable logic controllers with independent and redundant analog and digital input/output modules, DC power supplies, communication modules, etc., as required in the system cabinet. One programmable controller shall serve as back-up processor or its associated I/O fails. Both controllers shall contain an open protocol serial communications facility to allow monitoring via an Automated Logic control facility monitoring system of power flow, systems, breakers, batteries, and generator status, and all other alarms and parameters specified for annunciation in the paralleling switchgear.
 - b. A programmable controller register access panel shall be provided on the master door. This panel shall allow the operator access to the PC control without having to implement software setpoints, and load demand engine sequence positions.
 - c. A digital readout, solid state sequence display system shall be incorporated on the master door that will indicate the load demand engine starting and stopping sequence. If an engine is locked out, a lockout alarm indicator will flash for the respective generator.

3.04 OPERATIONAL OVERVIEW

- A. All system operation and control functions shall be coordinated and integrated such that during automatic and/or manual operation, no unsafe condition shall occur, no malfunction of intended operation shall occur, and the highest possible reliability of operation shall be maintained.
- B. Coordinate and integrate the functions and circuitry of all selector switches to ensure that the various settings available do not cause a malfunction of the intended system operation.
- C. Automatic Start Sequence: Provide interconnecting control circuits to produce the following normal operating function when a system start command is given to the engine generator standby system.
 1. Upon receipt of a start signal, start all the diesel generators.
 2. Close the generator output circuit breaker for the first generator to reach 90% operating voltage and a frequency of 58 Hz.

3. Once the next diesel (random selection) has reached operating voltage and frequency, it shall synchronize to the unit on-line and close into the bus.
 4. In like manner, each generator shall synchronize to the on-line units and close into the bus, independent of the other units, until all available units are on the bus.
 5. Provide positive lockout such that no two engine generators can be connected to a dead bus simultaneously.
 6. Upon receipt of a stop signal, all individual generator circuit breakers shall open and the engine generators shall continue to run at no load for an adjustable cool down period of time (5-40 minutes) before complete shutdown.
- D. Loss of Utility Sequence (Closed Transition Return): Provide interconnecting control circuits to produce the following normal operating function when the utility power is lost and the "Transfer Mode Selector Switch" is in the "Closed Transition" mode:
1. Initiate an adjustable time delay of .5-10 seconds.
 2. Upon expiration of the time delay, initiate an automatic start sequence.
 3. After the first engine generator is connected to the bus, open the main utility breaker.
 4. Provide load control contacts to shed non-priority load. The remaining connected load shall be sized for any one generator.
 5. Initiate an adjustable time delay (by use of the register access panel) of .5 to 10 seconds, and then close the generator main breaker.
 6. Provide load control contacts to add load, as generating capacity is added to the bus.
 7. Upon restoration of utility supply voltage, and after an adjustable period of time (0-60 minutes), the engine generator system shall synchronize with the utility power source, close the main utility breaker, transfer the load gradually to the utility source, and open the main generator breaker, providing a no-break (closed transition), soft load transfer, to the utility source.
 8. After the load has been transferred to the utility source, the individual engine generator breakers shall open and the engine generators shall continue to run at no load for an adjustable period of time from 0-5 minutes before complete shutdown.
- E. Loss of Utility Sequence (Open Transition Return): Provide interconnecting control circuits to produce the following normal operating function when the utility power is lost and the "Transfer Mode Selector Switch" is in the "Open Transition" mode:
1. Initiate an adjustable time delay of .5 - 10 seconds.
 2. Upon expiration of the time delay, initiate an automatic start sequence.
 3. After the first engine generator is connected to the bus, open the main utility breaker.
 4. Provide load control contacts to shed non-priority load. The remaining connected load shall be sized for any one generator.
 5. Initiate an adjustable time delay of .5 to 10 seconds, then close the main generator breaker.
 6. Provide load control contacts to add load, as generating capacity is added to the bus.
 7. Upon restoration of utility supply voltage, and after an adjustable period of time (0-60 minutes), the main generator breaker shall open and, after an adjustable time delay of (0 to 10 seconds), the utility main breaker shall close, providing a break-before-make (open transition), transfer to the utility source.
 8. After the load has been transferred to the utility source, the individual engine generator breakers shall open and the engine generators shall continue to run at no load for an adjustable period of time, from 0-5 minutes, before complete shutdown.
- F. Load Test Sequence (Actual Building Loads) - Closed Transition Load Assumption and Return: Provide interconnecting control circuits to produce the following normal operation functions when the "Test Normal" switch is selected to the "Load Test" position, and the "Transfer Mode Selector Switch" is in the "Closed Transition" mode.
1. Initiate an automatic start sequence.
 2. After a pre-determined number of engine generators are closed to the bus (as selected by the register access panel on the master control cubicle door), the standby system shall be capable of assuming bus load.

3. The generator bus shall be brought into synchronism with the utility and the main generator breaker shall close (closed transition) and parallel the utility and generator sources.
 4. The engine generators shall be gradually loaded until they have assumed the entire power requirements of the system load under test, then the utility main breaker shall open. This process shall occur in approximately 10-15 seconds. The generator control system shall regulate the output power of the engine generators so they never exceed the actual feeder loads (to prevent a reverse power situation where generator power is fed into the utility system).
 5. Should a power failure occur while in this condition, the emergency system would continue to operate the system loads on generators.
 6. When the "Test Normal" switch is returned to the "Normal" position after a power failure has occurred and the generators are supplying the load, the system will revert to the automatic loss of utility sequence described in Section 3.04, paragraph D.5.
 7. When the "Test Normal" switch is returned to the "Normal" position, and a power failure has not occurred, the engine generators shall synchronize with the utility power source, close the utility main breaker, gradually transfer the load back to the utility source, and open the main generator breaker (closed transition).
 8. After the load has been transferred back to the utility the individual engine generator breakers shall all open and the engine generators shall continue to run at no load for an adjustable period of time from 0-5 minutes before complete shutdown.
- G. Load Test Sequence (Actual Building Load) - Open Transition Load Assumption and Return: Provide interconnecting control circuits to produce the following normal operating function when the "Test Normal" switch is selected to the "Load Test" position, and when the "Transfer Mode Selector Switch" is in the "Open Transition" mode.
1. Initiate an automatic start sequence.
 2. After a pre-determined number of engine generators are closed to the bus (as selected by the register access panel on the master control cubicle door), the standby system shall be capable of assuming bus load.
 3. With the engine generators able to assume the entire power requirements of the load bus under test, the main utility breaker shall open and, after an adjustable time delay (0 to 10 seconds), the main generator breaker shall close (open transition).
 4. Should a power failure occur while in this condition, the emergency system would continue to operate the system load on generators.
 5. When the "Test-Normal" switch is returned to the "Normal" position after a power failure has occurred and the generators are supplying the load, the system shall revert to the automatic loss of utility sequence as described in Section 3.04, paragraph E.
 6. When the "Test-Normal" switch is returned to the "Normal" position, and a power failure has not occurred, the main generator breaker shall open and, after an adjustable time delay (0 to 10 seconds), the main utility breaker shall close, providing a break-before-make (open transition) transfer to the utility source.
 7. After the load has been transferred back to the utility, the individual engine generator breakers shall all open and the engine generators shall continue to run no load for an adjustable period of time from 0-30 minutes before complete shutdown.
- H. Generator Load Bank Testing: The switchgear PLC shall be capable of utilizing the remote load bank to test the generators.
1. Initiate the key interlock sequence to allow the Load Bank to connect to the selected main switchgear.
 2. Initiate start up of the selected generators to be tested.
 3. Indicate the desired time of the load testing. After the determined time the generators shall shut down and the input breaker shall trip open.
 4. If a power failure occurs during the testing, trip the load bank breaker and follow the procedure for assuming the load "Loss of Utility Sequence (Closed Transition Return)"

- I. Temp Generator Operation: The switchgear PLC shall be capable of utilizing the remote temporary generator as a substitute to one of the normal generators out of service. When this mode is selected the temporary generator will always be started first and the second generator will sync to it. The operation of the switchgear will be similar to the "Loss of Utility Sequence (Open Transition Return)"

3.05 LOAD CONTROL CIRCUITS

- A. Provide control circuits, interlocks, and relays to protect against overloading. Provide priority load control contacts as described in 3.04 above.
- B. A programmable controller shall be provided for the system to allow only predetermined loads to be closed to the system bus, until additional engine generators are connected in parallel to the main switchboard bus.

If the programmable controller fails, the system shall allow all engines to close to the bus and take on load, automatically, if utility power fails.

- C. The load shedding controls shall also be backed-up, with a bus frequency monitor which shall shed all non-essential loads during a bus under frequency condition.

3.06 LOAD DEMAND/ENGINE START/STOP SEQUENCE

- A. In a normal power failure operation, load demand sensing will, after a (0 to 60 minute adjustable) time delay, be placed into operation. The programmable controller shall monitor the load on the emergency bus and will initiate signals to subtract and add generators as required. An indicating lamp on the master control cubicle will be flashing during the 0 to 60 minute time delay and will be on constant, when the system is operating in load demand mode.
- B. The engine starting and stopping sequence can be changed through the Register Access Panel.
- C. If the sequence is changed during an automatic operation, any engine on line will remain on line. If the engine selected as the base engine is not on line, it will be immediately started up and placed on line. The engine generators that are selected as sequence position #2 and #3 will be added in sequence to the bus and subtracted in reverse sequence. Should an engine be locked out of the system it will be skipped over and the next engine in sequence will be started as required.
- D. Backlit engraved indicating windows shall be provided on the master control cubicle to light when the loading of the generating system reaches preset "Decreasing Load", "Increasing Load" and "Overload" setpoints. These lights are flashing when timing and are on constant when timed out.
- E. The setpoints shall be field adjustable through the Register Access Panel. The "Overload" setpoint is adjustable from 90 to 125% of each engine's rated loading. The "Increase" is adjustable from 60 to 100% (or "Overload" minus 10%, whichever is smallest) of the on line capability of the system. The "Decrease" is adjustable from 40 to 80% (or "Increase" minus 10%, whichever is smallest) of the on line capability of the system after the decrease.
- F. The overload and increase time delays shall have "inverse time characteristics" - the higher the loading - the shorter the time delay. The settings shall be programmable through the Register Access Panel. The ranges are 0 to 10.0 seconds for the overload setpoint, and 0 to 99.9 for the increase time delay. The decrease time delay shall be adjustable from 0 to 99.9 seconds.

3.07 ENGINE GENERATOR SELECTOR SWITCH

- A. Provide a four-position engine selector switch labeled, "Lockout/Reset-Off-Auto-Run", on each engine generator control panel cubicle door."

- B. When the selector switch is in the "lockout/reset" position, the generating plants shall be locked out. Whenever the selector switch is placed in the "lockout/reset" position while the engine generator is operating, it will immediately shut down and its circuit breaker will trip.
- C. An "off" position shall be provided to allow a normal shutdown, with a time delay to allow the engine to cool after operating under load. Whenever the engine selector switch is placed in the "off" position while the engine is operating, the generator circuit breaker will trip, but the engine will continue to operate until the expiration of time delay setting of the idle relay.
- D. When the engine selector switch is placed in the "auto" position, the engine generator shall be on standby and shall start whenever an engine start signal is received from the automatic transfer system. When the utility power returns, and the transfer system signals the engine generator to shut down, the circuit breaker will be tripped, and the engine will continue to operate for the idle time delay period before shutting down in readiness for the next power failure.
- E. When the engine selector switch is in the "run" position, the engine will start and come up to speed. It will continue to run until the selector switch is returned to "off" or "lockout/reset" position. This position is to be used for testing or for manual operation.

3.08 MASTER CONTROL "NO LOAD TEST-NORMAL-LOAD TEST" SWITCH (KEY OPERATED)

- A. Provide a three-position test switch labeled "No Load Test-Normal Load Test" in the master control section to permit operation and testing as follows:
 - 1. When the switch is placed in the "No Load Test" position, automatic start of the generators shall occur and all automatic synchronizing functions completed, except the load shall remain connected to the normal source, unless the normal power source should fail during the test procedure. Future generator shall be automatically synchronized and paralleled on the main bus at no load.
 - 2. Returning the switch to the "normal" position shall initiate the shutdown of the engine generators, and restore all equipment to normal operation.
 - 3. When switch is placed in the load test position, automatic start of the generator will occur and all automatic synchronizing functions completed. The load bank circuit breaker shall close and load shall be applied (via remote, portable load banks by others) to the emergency system. In the event of a utility power outage while performing a load test, the load bank circuit breaker shall be tripped and the system automatically revert to emergency operation. Switchgear supplier is to coordinate with the supplier of the portable load banks for proper cooling fan operation requirements.

3.09 FACILITY LOAD TEST SWITCH (Two Position)

- A. Provide a two position facility load test switch on the master cubicle door to permit operation as follows:
 - 1. When the switch is placed in the "Facility Load Test" position, a signal is sent to the utility main switchgear initiating a simulated loss of utility power. The system shall operate as described in Section 3.01.
 - 2. Returning the switch to the "Off" position shall initiate a retransfer to the utility as described in Section 3.01.

3.10 MASTER "MANUAL-AUTO" CONTROL SWITCH (TWO-POSITION)

- A. Whenever the master "manual-auto" control switch is placed in the "manual" position, the engine generator power circuit breakers and synchronizing shall be operated manually. A swing panel in the master control section shall be provided with synchroscope, synchronizing lights, frequency meter and bus voltmeter for manual synchronizing through the engine generator power circuit breaker control switches, the synchroscope switches, and the frequency meter switches on the engine generator control section door.

3.11 GENERATOR AUTOMATIC PARALLEL DISABLE SWITCH

- A. Provide a two position generator automatic paralleling disable switch on each generator control cubicle door to completely disable the generator automatic starting and paralleling capability. This switch will allow an engine generator to serve a dedicated emergency load in the event of a catastrophic normal incoming service equipment failure. Refer to the project single line diagram for each generator dedicated load.

3.12 FAIL TO SYNCHRONIZE TIME DELAY RELAYS

- A. A fail to synchronize time delay relay shall be provided for each generator to terminate the operation of the synchronizer and sound a warning horn, in the event the generator is unable to be synchronized within an adjustable period of time, approximately 0-3 minutes. After failing to synchronize automatically, the operator, at his discretion, shall be able to connect either one or all the machines to the emergency bus by turning the master control switch to the manual position, and by operating the manual synchroscope system and the circuit breaker control switches.

3.13 OPERATION OF THE FAIL LIGHT, LOCKOUT, AND ALARM SYSTEM

- A. Each engine generator power circuit breaker and control section shall be provided with separate alarm relays and alarm lights, to shut down the engine generator, disconnect it from the main bus, and illuminate a light to indicate the nature of the failure.
- B. If the generating plant is running automatically with the master selector switch in the "AUTO" position, a failure at the engine shall cause the respective fail light to light and the engine will be shut down and locked out of the automatic mode of operation.
- C. To reset an engine generator after a failure while in automatic operation, the engine selector switch shall be rotated to the "lockout/reset" position.
- D. After the failure has been corrected, the engine generator shall then be returnable to a standby condition by returning the selector switch to the "AUTO" position.

3.14 SELECTOR SWITCH COORDINATION

- A. Coordinate the functions and circuitry of the various selector switches, to insure that the various settings available do not cause malfunction in the intended system operation.

3.15 EQUIPMENT

- A. Paralleling Generator Control Switchgear
1. The master control cubicles shall be furnished with the following basic components, and any additional equipment necessary to provide for a complete and dependable system:
 - a. One (1) master control and synchronizing panel to control the operation and synchronization of the engine generators
 - b. One (1) solid state best battery selector system (best battery selector)
 - c. One (1) voltmeter selector switch reading phase to phase and phase to neutral
 - d. One (1) load demand "on-off" switch (key operated) with increase load push-button
 - e. One (1) bus voltage/frequency failure relay, with fail light and reset push-button
 - f. One (1) fail to synchronize time delay relay
 - g. One (1) station alarm horn, with silencer switch and light
 - h. One (1) master "auto-man" switch, with red light
 - i. One (1) master "no load test - normal-load test" switch (key operated, two-position)
 - j. One (1) facility load test switch (key-operated, two position)
 - k. One (1) load shed and re-add control panel, with a manual load shed bypass switch (key operated)
 - l. One (1) shed non-essential load push-button

- m. One (1) re-add non-essential push-button
- n. One (1) back lit annunciation panel with engraved nameplates for the following alarm conditions:
 - i. Bus overvoltage
 - ii. Bus undervoltage
 - iii. Bus over frequency
 - iv. Bus under frequency
 - v. Main tank low level
 - vi. Control not in automatic
 - vii. Critical control voltage failure
 - viii. AC control voltage failure
 - ix. Horn silenced
 - x. Load shed bypassed
 - xi. Load shed activated
 - xii. System test
 - xiii. Spare
 - xiv. Spare
 - xv. Spare
- o. One (1) set of control wiring, fuses, fuse blocks, terminals, nameplates, etc., as required. All wiring shall be labeled at both ends
- p. Provide a terminal strip in the master control cubicle, with system alarm signals wired out for remote annunciation and remote load priority contacts.
- q. One (1) programmable controller, General Electric Series 90-30, complete with analog, and digital, input/output modules, power supplies, communication modules, etc., as required.
- r. One (1) PLC Register Access Panel, with bus KW readout.
- s. One (1) engine sequence display to indicate operating sequence of the engine generators.
- 2. Synchronizing Swing Panel (Mounted in Master Cubicle Door)
 - a. One (1) bus AC voltmeter, 0 to 600 volt scale
 - b. One (1) synchroscope
 - c. Two (2) synchronizing lamps
 - d. One (1) frequency meter, for station bus and generator units, dial type, 55 to 65 Hertz scale
- 3. Two generator control cubicles shall be furnished, each with the following basic components, and any additional equipment necessary to provide for a complete and dependable system.
 - a. One (1) AC voltmeter, 0 to 600 volt scale
 - b. One (1) voltmeter selector switch, reading phase to phase
 - c. One (1) AC ammeter, scale as required, 5 ampere movement
 - d. One (1) ammeter selector switch, four position
 - e. One (1) AC wattmeter, scale as required
 - f. One (1) automatic synchronizer, Woodward type SPM-A, or as manufactured by the manufacturer of the engine governor controller
 - g. One (1) frequency meter switch, with "Bus-Off-Generator" nameplate (key interlocked)
 - h. One (1) synchroscope switch, with "On-Off" nameplate (key interlocked)
 - i. One (1) circuit breaker control switch
 - j. One (1) generator automatic parallel disable switch
 - k. One (1) engine selector switch, with "Lockout/Reset-Off-Auto-Run" nameplate
 - l. One (1) mounting and wiring of governor control unit, as supplied by the engine generator manufacturer
 - m. One (1) mounting and wiring of the voltage regulator, as supplied by the engine generator manufacturer
 - n. A separate, independent, heavy-duty, automatic starting control and failure system shall be provided in each generator control cubicle to control the starting, stopping, and monitoring of each engine generator. The engine cranking system shall permit at least four (4) cranking attempts of 10 seconds duration, with rest periods of 10 seconds. Overcrank lockout shall occur after four (4) unsuccessful cranking attempts. A means shall be provided to allow for a continuous cranking cycle, if required.
 - o. One (1) back lit annunciator with red indicators for shutdown failure, and amber indicators for alarm conditions. The annunciator windows shall be engraved to indicate the nature of the

alarm condition or failure. All alarms will be of the "ring-back" type, i.e., any time the alarm horn is silenced for a failure, the next failure or alarm will re-energize the alarm horn. The following fail circuitry and annunciation shall be provided for the engine control cubicle:

- i. One (1) approach low oil pressure; alarm only.
- ii. One (1) low water temperature; alarm only.
- iii. One (1) approach high water temperature; alarm only.
- iv. One (1) battery charger failure; alarm only.
- v. One (1) control voltage failure; alarm only.
- vi. One (1) overspeed; immediate shutdown.
- vii. One (1) overcrank; immediate shutdown.
- viii. One (1) reverse power; immediate shutdown.
- ix. One (1) overcurrent (circuit breaker trip and lockout); immediate shutdown.
- x. One (1) failure to synchronize; immediate shutdown.
- xi. One (1) low lube oil pressure; immediate shutdown.
- xii. One (1) high water temperature; immediate shutdown.
- xiii. One (1) low fuel day tank.
- xiv. One (1) high fuel day tank.
- xv. Engine locked out
- xvi. Engine running
- xvii. Automatic paralleling disabled
- p. Provide a terminal strip in the generator control cubicle, with the above engine generator alarm signals wired out for remote annunciation
- q. A separate backlit display shall be provided with engraved windows for the following circuit breaker status indications:
 - i. Circuit breaker opened
 - ii. Circuit breaker closed
 - iii. Circuit breaker drawn out
 - iv. Generator running
- r. One set of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be labeled at both ends. Wiring labels shall match manufacturer's drawings.

B. Utility Source/Generator Circuit Breaker Switchgear

1. Two generator main feeder circuit breaker sections shall be furnished for each generator switchgear as required, each to include the following basic components, and any additional equipment necessary to provide for a complete and dependable system:
 - a. Two (2) 3200/3000 ampere frame, electronic trip, molded case draw out type circuit breaker for generator feeds.
 - b. One (1) Set of (3) potential transformers.
 - c. Two (2) sets 5000 ampere, 3 phase main bus, with separate ground bus sized minimum 50% of the switchgear rating for generator synchronized feed to utility feed.
 - d. One (1) circuit breaker position indicating lights (red and green).
 - e. One (1) set of three phase underground feeder breaker to load bank switchboard.
 - f. One (1) load of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be numbered and identified at both ends.
2. Distribution circuit breakers shall be draw out type. Refer to accompanying single line drawing for number of breakers with following feature:
 - a. Breakers shall be encased type with microprocessor electronic trip units.
 - b. One (1) set circuit breaker position indicating lights (red and green).
 - c. One (1) lot of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be numbered and identified at both ends.
3. One load bank/ temp generator/ temp chiller circuit breaker section shall be furnished with 2500A trip breaker and any additional equipment necessary to provide for a complete and dependable system.

3.16 CONSTRUCTION LOW VOLTAGE

A. SWITCHGEAR ENCLOSURE

1. Switchboard framework
 - a. Freestanding, floor mounted, indoor type, NEMA 1 Class III.
 - b. Dead front, dead rear.
 - c. Fabricated on a die-formed steel base or base assembly, welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting.
 - d. Die-pierce holes for connecting adjacent sections to assure alignment and facilitate future additions.
 - e. Bolts, nuts and washers shall be cadmium plated, rustproof metal.
 - f. Designed to withstand the mechanical stresses caused by rough handling during shipment, in addition to the electrical and mechanical stresses that occur during operation of the assemblies.
 - g. Framework formed of code gauge steel (12 gauge minimum) suitable for anchorage to floor.
 - h. Rugged steel assemblies with bracing, reinforcing gussets and jig-welding, to assure rectangular-rigidity. The sections shall be completely metal enclosed.
 - i. Each switchgear section shall have open bottom, as required, for ready installation and termination of conduits. Top and bottom conduit and bus duct area is to be clearly shown and dimensioned on the shop drawings.
 - j. All side, top, front and back panels shall be removable, attached by bolts, and small enough for easy handling by one person.
 - k. Front and rear doors, hinged mounted, equipped with lock type operating handles, shall be installed on all cubicles for easy access.
 - l. Individual front doors will be supplied for each power circuit breaker compartment. Layout will be reviewed when shop drawings are submitted for review.
 - m. Suitable means shall be provided near top and bottom of switchboard to insure adequate ventilation for all equipment within the switchboard assembly.
2. Dimension
 - a. Conform to the arrangements and details, as shown on the drawings, and to the space designated for installation.
 - b. Construct so highest operating handles do not exceed 6'-6" above floor.
 - c. Provide adequate gutter space in all sides of switchboard sections. Arrange for clearance to permit good accessibility of feeder conductors and bus ducts into switchboard.
3. Painting: All steel parts shall be prepared for painting by a five (5) step cleaning, phosphatizing and sealing process. The parts shall then be painted ANSI 61 gray, utilizing polyester powder coating applied by the electrostatic method and cured in a baking oven. This finish shall be suitable for outdoor, as well as indoor applications.
4. Bus Bars and Interconnections
 - a. General
 - i. All buses and stub connections shall be silver-plated copper. All buses shall be plated after bending and machining.
 - ii. 480 volt, three phase, 3 wire, 60 Hertz, unless otherwise specified.
 - iii. Size: Size such that the current density is not greater than the current carrying capacity of the rectangular copper bars, as required by UL and NEMA standards. Heat rise tests shall be in accordance with UL 1558.
 - b. Buses and stub connections shall limit temperature rise to 30° C at load current capacity at 40° C ambient.
 - c. If a rear compartment is utilized to house any control components, grounded metal personnel protection barriers shall be provided to isolate the bus compartments.
 - d. Bus bar and interconnection joints shall be silver-plated, constant-high-pressure type, with Grade 5 steel, cadmium plated, rust-proof bolts, nuts and compression washers.
 - e. Bracing: Bus bracing capacity shall be equal to or greater than frame rating of the main breakers serving same.
 - f. Ground Bus: 50% current-carrying capacity of the engine generator control switchgear bus, which extends across the entire width of the switchboard assembly.
 - g. Bus phase designations front to back, top to bottom, left to right shall be A, B, C, respectively when viewed from the front.

- h. Main horizontal bus bars between sections shall be located in switchboard to permit maximum conduit and wiring area.
- i. The continuous ampere rating of the main power bus shall be as shown on the contract drawings, and the bus connections to the power circuit breakers shall match the circuit breaker frame size to which it is connected.
- 5. Compartments
 - a. The control sections shall be isolated by grounded steel barriers from the circuit breaker and bus sections. Control voltage will be 120 VAC or less, in these sections.
 - b. Power circuit breakers shall be installed in individual front compartments with separate doors.
 - c. Buses shall be installed in rear compartments.
- 6. Instrument and Control Wiring
 - a. Instrument and control wiring within the switchboard sections shall be of flame retardant type "SIS," number 14 gauge minimum, extra flexible, 41 strand, and tinned copper, approved for switchboard use.
 - b. All wire terminations made at terminal blocks, meters, relays, and other similar devices, shall be made with ring tongue or locking spade crimp type lugs.
 - c. All wiring between shipping sections shall be installed by manufacturer. Wiring shall be disconnected at one end, for shipping.
 - d. Each internal interconnecting wire shall be identified by means of a suitable permanent marker at each end. Wire numbers shall match the manufacturer's interconnection drawing.
 - e. Terminal blocks shall be supplied and clearly marked for wiring that will be installed or reconnected by the Contractor, including wiring between shipping sections.
 - f. Terminal blocks shall be equipped with screw type terminals for accommodating ring tongue or, locking spade wire terminations, with high insulating barriers. All terminal screws to have lock washers.
- 7. Miscellaneous
 - a. All instruments shall be 4½" switchboard type, 1% accuracy. Instrument control switches shall be heavy-duty, rotary switchgear type, rated 30 ampere at 600 VAC.
 - b. The system controls shall utilize heavy-duty industrial grade, controls and relays. All synchronizing and failure circuit relays shall embody the fail safe principle of dual contacts in parallel, in transparent enclosures.
 - c. All failure and synchronizing relays shall be provided with plug-in bases to facilitate removal and testing.
 - d. The switchgear circuit breakers shall be 3 pole, draw-out type, provided with self aligning, line-side and load-side disconnecting devices. Breakers shall be electrically operated (120 VAC spring charge and close, 24 VDC trip). Breakers that have the same ratings shall be interchangeable with each other. Breakers shall be equipped with the "stored energy operation". Each breaker shall have three normally open and three normally closed contacts for remote indication of breaker closed, breaker open, and breaker tripped positions for BMS system and bell alarm contacts. Provide cell position switches for all breakers for remote indication of rack-in and rack-out.
 - e. Externally visible, permanent nameplates shall be provided to identify each instrument, instrument switch, meter, protective relay, control switch, indicating light, circuit breaker compartment. Relays shall be designated as to use, and as to the phase to which they are connected.
 - i. Nameplates shall be laminated plastic, and attached with screws. Characters shall be white engraved on a black background.
 - ii. Nameplate inscriptions will be reviewed and determined when shop drawings are submitted for review.
 - f. Equipment and terminal blocks within the compartments shall also be suitably identified.
 - g. A portable circuit breaker lifting device shall be provided.
 - h. Mounting and wiring of voltage regulators, voltage adjusting rheostats, governor controls, and associated equipment shall be by the switchboard manufacturer. These components shall be furnished to the switchgear manufacturer by the engine supplier.
 - i. The switchgear manufacturer shall be responsible for providing the coordinating wiring diagrams showing the electrical connections between the control switchgear and the engine

generators, for use by the Electrical Contractor and engine generator service personnel during installation and checkout of the equipment.

3.17 FIELD SERVICE

- A. After installation by the Electrical Subcontractor, the switchboard manufacturer shall provide the service of a competent factory based service engineer to instruct the Electrical Contractor and Owner, and to coordinate the installation of the engine generator units. He shall assist in placing the equipment into operation and provide instruction, as required, to the person or persons who are delegated by the Owner to operate the equipment.
- B. This service shall include three separate visits by the factory service engineer as follows:
 - 1. Pre-installation coordination meeting with the engine generator distributor, Electrical Contractor, Consulting Engineer, and Owner to coordinate the installation and interconnection of the engine generator control switchgear with the engine generator equipment.
 - 2. Post installation start-up and testing assistance, prior to system turnover, and initial instruction and training period for operating personnel. This trip shall include all service required to checkout the emergency system and demonstrate the operation for final acceptance by the owner.
 - 3. Approximately six months after the complete system turnover, a visit shall be made to provide instruction for operating personnel on complete operation and maintenance program.
- C. The switchgear manufacturer shall maintain a competent service organization that is available on a 24-hour call basis.
- D. Due to the critical nature of coordination and startup, all vendors wishing to bid to these specifications shall be required to adhere to the testing and installation section outlined above. In addition, manufacturer shall state location of nearest factory employed (resident) field service location in their bid. As protection to the owner, manufacturers wishing to limit themselves to a maximum number of field service visits must so state their bid, and provide the charges for additional visits in the form of published field service rates including overtime and holidays. It shall be provided for evaluation. Perspective vendors may not employ contract personnel for any service in 3.17 A through C above non-compliance with provisions in this section shall be cause for automatic rejection of bid.

3.18 SUBMITTALS

- A. Shop Drawings: Submit shop drawings, prior to starting work on the engine generator control switchboard, for review as specified elsewhere in these specifications.
- B. Complete Structural Drawings showing:
 - 1. Arrangement
 - 2. Dimensional plan and elevation, front view, side views, and other pertinent elevation views.
 - 3. Conduit entrance locations and dimensions for both bottom and top entrance.
 - 4. Weight of equipment.
 - 5. Breaker lifting rail/lifting details.
- C. System description
- D. System operation
- E. List of sub-assemblies, devices and part numbers.
- F. Base plan, show dimensions of base with anchoring.
- G. List of all performance data and component bulletins.

PART IV - EXECUTION4.01 FACTORY ASSEMBLY AND TEST

- A. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After complete assembly, the unit shall be tested for operation under simulated service conditions by impressing properly phased voltage and current on all components to assure accuracy of wiring, correctness of the control scheme and functioning of the equipment. Dielectric tests of all current carrying parts shall be conducted in accordance with industry standards.
- B. Provide a minimum of fourteen days advance notice of the test, as the Owner and Engineer will be witnessing the test.
- C. Materials and apparatus under these specifications shall be subject to inspection by the purchaser. Purchaser's inspector shall, during working hours, have access to all parts of the shop where material is being manufactured and shall be provided with all reasonable inspection facilities. Release of material shall not relieve manufacturer from contract responsibility nor invalidate any claim which purchaser may make because of unsatisfactory material or construction.
- D. All routine factory tests shall be completed prior to beginning witnessed tests. Witnessed tests shall be in addition to those deemed necessary by the manufacturer and at a minimum shall consist of the following:
 - 1. Alarm and Functional Tests
 - a. Verify the function and operation of all relays, meters, controls, operator adjustments, lights, alarms, breakers, key interlocking and trip condition.
 - b. An individual test to verify the specified operation of all contacts and signals being supplied to the building management system.
 - 2. Dielectric Test
 - 3. Each switchgear will withstand 1500 volts RMS, at 60 Hz frequency, successively applied for one minute between each electric circuit and all other electric circuits with metal parts grounded. Solid state devices may be removed with the circuits during this test. The equipment will not be damaged during tests and will function satisfactorily when installed in the system after completion of the dielectric tests.

4.02 DISASSEMBLY AND SHIPMENT

- A. Upon completion of testing and before crating and shipment, all parts to be disassembled shall be matchmarked to facilitate erection in the field. The substation shall then be disassembled into the required number of parts necessary for shipping. Each part shall be covered with a heavy kraft paper and placed in an individual crate for shipment.

4.03 INSTALLATION

- A. Install switchgear plumb and level where indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products fulfill requirements.
- B. Coordinate switchgear installation work with electrical raceway and cable work, as necessary for proper interface.
- C. Provide connection of conduit, busduct, and other raceways as required.

4.04 SITE ACCEPTANCE TESTS

- A. Field Engineers for Start-Up: After delivery, the seller shall provide one or more qualified, experienced field engineers to assist and supervise start-up commissioning and testing. The Engineer will advise at least ten days in advance of the date when such field engineering support will be required. Such field engineering personnel shall report promptly at the time and place designated by the Engineer and shall be assigned to work continuously until released by the Engineer. Working schedule for these technical representatives will be determined by the Project Engineer.
- B. A complete functional test of the switchgear shall be performed at the site, after installation, to ascertain that:
 - 1. The equipment has suffered no impairment in performance since factory tests were made.
 - 2. The installation is in accordance with these specification requirements.
- C. System test power requirements shall be provided by the Owner's AC service equipment.
- D. The purchaser's personnel will witness the site acceptance test.

4.05 WARRANTY

- A. The manufacturer shall warrant the satisfactory and successful operation of all components, material, and structure furnished under these specifications at the rating, under the conditions and for the service specified. The manufacturer further warrants the equipment to be as represented and specified and shall warrant against any and all defects in design, material, and workmanship, and shall, upon written notice by the purchase, remedy such defects as develop under the specified and ordinary use of this apparatus, within five years of actual service, such service to begin after final acceptance by the builder.
- B. The manufacturer's authorized service agent shall provide person-to-person voice communication within one hour of owner's request for service. Manufacturer's agent shall have means of recording all requests for service made via telephone. This shall include electronic time tag.

4.06 SPARE PARTS

- A. Provide a complete spare parts list, including recommended quantities and prices.

4.07 OPERATION INSTRUCTIONS AND MAINTENANCE MANUAL

- A. After completion of work and start-up of the equipment at the job site, deliver to the Contracting Officer, copies of operating instructions, maintenance manuals and drawings presenting full details for care and maintenance of each item of equipment furnished and/or installed under this Contract.
- B. Each manual shall contain the operating and maintenance information and parts lists furnished by the manufacturer, for all equipment provided in the Contract. When necessary, provide supplemental drawing to show system operation and servicing and maintenance points. For all electrical components, furnish wiring and connection diagrams. Manuals shall include instructions required to accomplish specified operation and functions. Data shall be neat, clean, legible copies. Drawings shall be accordion folded. Non-applicable information shall not be included. Five (5) sets of manuals shall be furnished to the Owner.
- C. Switchboard drawings and wiring diagrams shall be furnished complete and up to date at the completion of start-up and system acceptance by the Owner. Drawings and wiring diagrams shall include any field modifications or changes to reflect actual as built conditions.

4.08 KIRK – KEY INTERLOCK SYSTEM

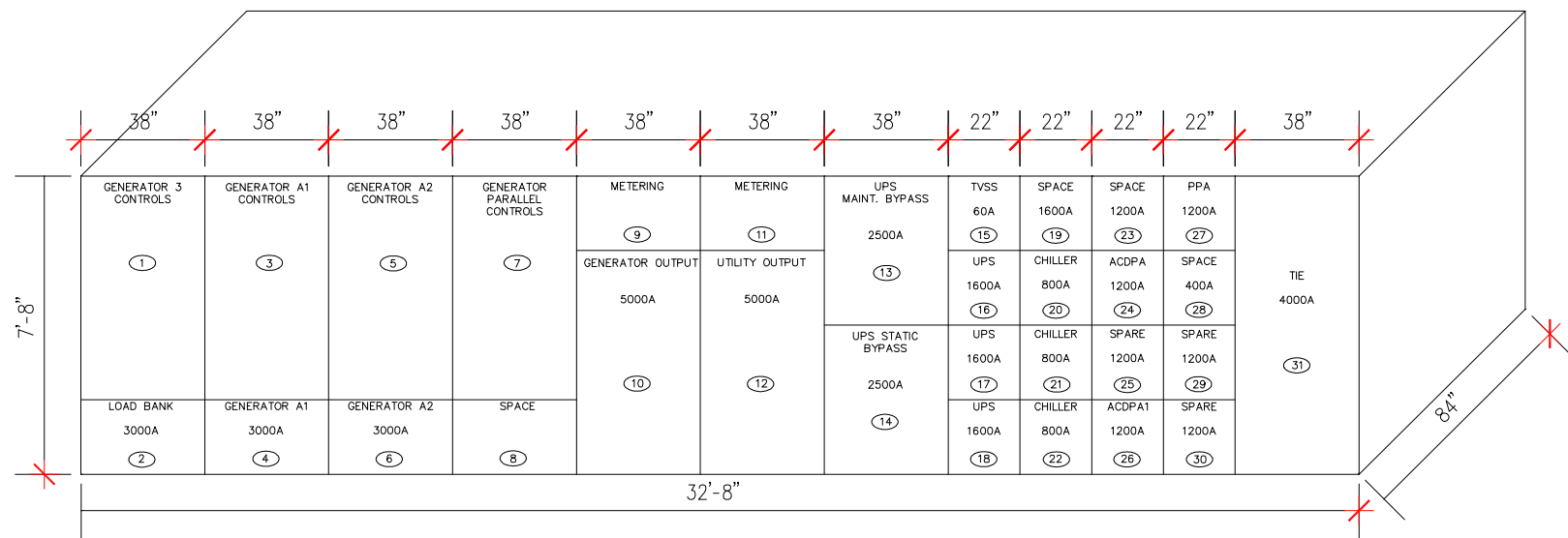
- A. Kirk key interlock system that will be provided is indicated below:

Load Bank Operation at MSA (Typical for MSB):

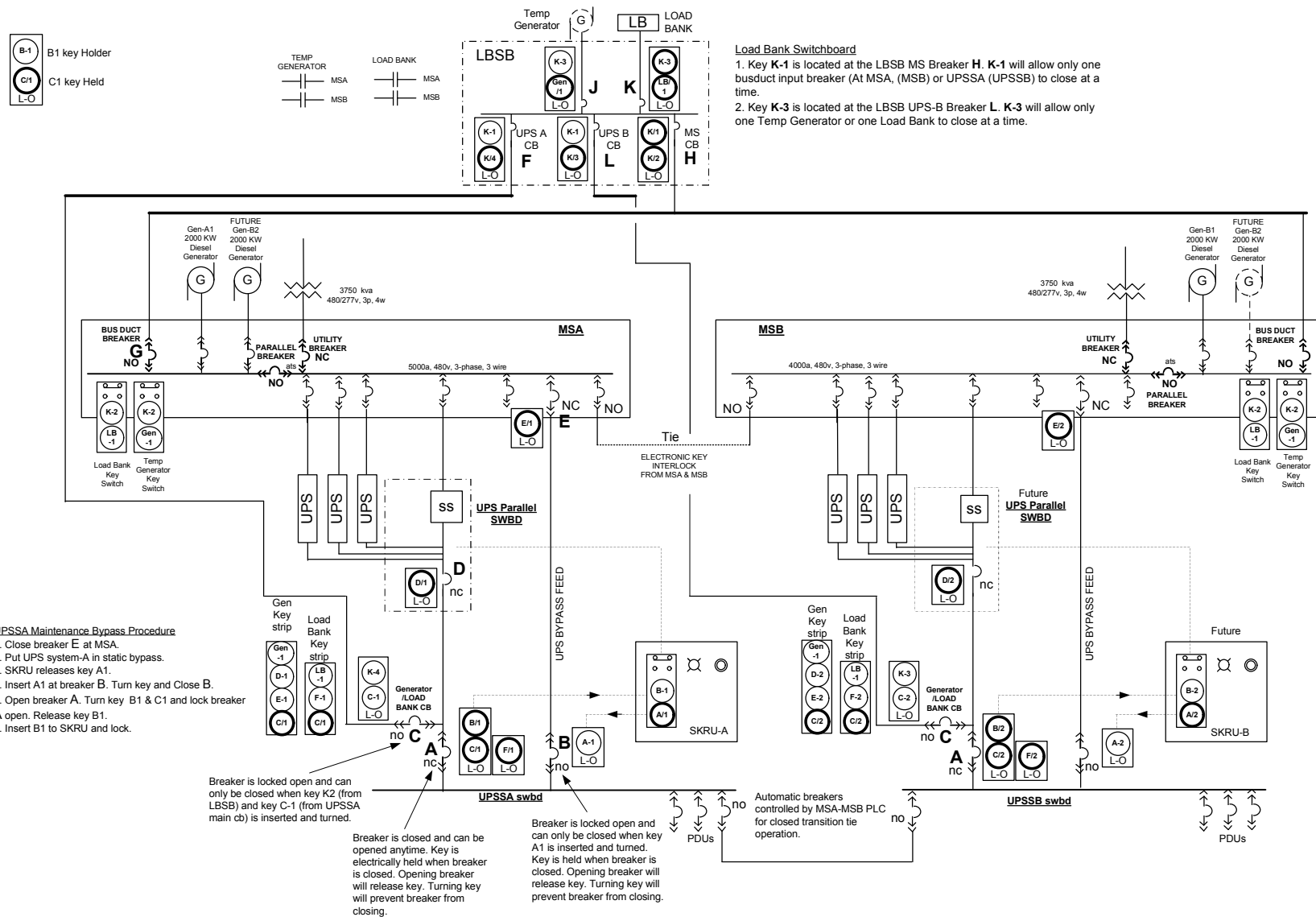
1. (At LBSB) Insert key K-3 at Load Bank breaker K, close breaker. Remove key LB-1.
2. (At LBSB) Insert key K-1 at MS Bus Duct breaker H, close breaker. Remove key K-2.
3. (At MSA) insert key K-2 and LB-1 at breaker G Load Bank key box. A permissive contact at the key box allows the PLC program at MSA to operate the generators on load bank.
4. If a power outage occurs during testing, breaker G will be tripped open and the ATS operation at MSA will function normally.

Temporary Generator Operation at MSA (Typical for MSB):

1. (At LBSB) Insert key K-3 at Temp Generator breaker J, close breaker and remove key Gen-1.
2. (At LBSB) Insert key K-1 at MS cb H. Close breaker H, remove key K-2 and insert K-2 and Gen-1 at breaker G "Temp Gen Key Switch" at MSA.
3. (At MSA) Put the PLC controller in the Temp Generator mode. The PLC will verify that the Temp Generator Breaker is closed at LBSB (and from the contact at the "Temp Gen Key Switch") and allow breaker G to close.
4. If a power outage occurs the Temp Generator will start first and come on the bus. The main generators will then start up and sync to the Temp Generator.
5. All 5. All closed transition functions of the ATS will be disabled during Temp Generator operation. All transfers are Open Transition.



1 MSA / MSB
N.T.S.



END OF SECTION 16428

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED****A. General Construction:**

1. Furnish distribution switchboard, LBSB dead front type, completely metal enclosed, self-supporting structure independent of wall supports, front accessible. Voltage rating shall be 480V, 3 Phase, 3 Wire as indicated on the drawings. It shall consist of the required number of vertical sections bolted together to form single rigid switchboards, as indicated. The sides and rear shall be covered with removable screw-on plates. All edges of front cover panels shall be formed.
2. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL891. Where switchboards are used as service entrance equipment, they shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided.
3. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. All control wires shall be marked.
4. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and provided with vendor supplied floor sills to be set level by contractor.
5. Furnish cable pull sections or top cable pull boxes as required for cable bending radius.
6. Key interlock shall be provided at all breakers.
7. A rotary selector switch shall be provided for remote start of the temp generator by the selected main switchboard.

B. Bussing

1. All bus bars shall be copper with bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65° C rise based on UL tests, and rated to withstand mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current of 150,000 amperes symmetrical at rated voltages or as shown on the drawings. Provide full capacity neutral where a neutral is indicated on the drawings.
2. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. An incoming ground lug shall be furnished. Other ground lugs for feeder circuits shall also be supplied as shown in the schedules on the drawings.
3. All hardware used on conductors shall be high-tensile strength and plated.
4. All terminals shall be of the anti-turn solderless type suitable for copper cable of sizes indicated for 75° C cable.
5. Bus bars shall be rated 3000A continuous.
6. Provide ground bus of capacity 50% of main bus.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS****A. Acceptable manufacturers are as follows:**

1. Eaton Cutler-Hammer
2. General Electric
3. Siemens
4. Square D

2.02 SWITCHBOARD TYPE**A. Front Accessible with Panel Mounted Feeder Devices.**

1. Switchboard LBSB shall be suitable for outgoing cables and shall be provided with termination lugs.
2. Switchboard shown mounted against a wall shall be of front accessible construction. All sections of the switchboard shall align so that the back of the complete structure may be placed flush against a wall.
3. Construction shall allow maintenance of incoming line terminations, main device connections, and all main bus bolted connections to be performed without rear access. The feeder or branch devices shall be removable from the front and shall be panel mounted with the necessary device line and load connections front accessible. Provide lugs on all devices for cable sizes shown on drawings.
4. Switchboards shall have hinged door (s) for access to breakers. Door (s) shall not exceed two feet in width.
5. Provide three (3) white pilot lights on the switchboard indicating power availability. Pilot lights shall be LED type. Provide potential transformer and fusing for the operation of LED lights.

2.03 CIRCUIT BREAKERS TYPE

A. Provide insulated case circuit breakers of following frame and trip ratings:

1. Three (3) 3200A frame, 3000A trip, 3 pole
2. Two (2) 2500A frame, 2500A trip, 3 pole

Circuit breakers shall be 100% rated and shall be suitable for operation on 480V, 3 phase system and shall withstand a minimum of 150,000A symmetrical short circuit current.

Breakers shall be furnished with key interlock system. Normally all the breakers shall be in "OFF" position. Only one breaker could be closed at one time (Load Bank, Chiller & Temp generator). Breakers shall be type 'R' frame with electronic RMS. Each breaker shall have (4) dry contacts for remote indication.

- B. Branch devices shall be insulated case type circuit breakers.
- C. Devices shall have a minimum interrupting rating of 150,000 amperes at 480 volts or as shown on drawings.
- D. Devices shall be manually operated (MO).
- E. Devices shall be equipped with ground fault interrupting (GFI).

2.05 NAMEPLATES

- A. Engraved nameplates shall be furnished for all mains and feeder circuits with designation and circuit number as indicated on the drawings. Furnish master nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.

2.06 ENCLOSURES

- A. Enclosures shall be NEMA 1, Class III, of indoor-ventilated construction as shown on the drawings. Control power shall be obtained from an internal control power transformer.

2.07 SUBMITTALS

- A. Vendor shall provide dimensions and weight of the switchboard offered with their proposal.
- B. Final submittals shall include:
- a. Dimensions and weight
 - b. Shipping splits

- c. Point-to-point wiring
- d. Elementary and schematic diagrams

2.07 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 and use the manufacturer's standard process.

Notes:

1. Dimensions shown are estimated. The overall dimension "Not to Exceed 8-feet 10-inches".

END OF SECTION 16429

***** PRE-PURCHASED EQUIPMENT *******PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following types of transformers with medium-voltage primaries:

- 1. Two (2) 3,750 kVA (X/R=7.0) Pad-mounted, liquid-filled transformers.

1.3 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Diagram power signal and control wiring.
- C. Coordination Drawings: Floor 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:
 - 1. Underground primary and secondary conduit stub-up location.
 - 2. Dimensioned concrete base, outline of transformer, and required clearances.
 - 3. Ground rod and grounding cable locations.
- D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems". Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Qualification Data: For testing agency.
- F. Source quality-control test reports.
- G. Field quality-control test reports.

- H. Follow-up service reports.
- I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.
- J. Pad Lock provisions shall be made on both primary and secondary access doors.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2.
- E. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.
- F. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store transformers protected from weather so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.7 PROJECT CONDITIONS

- A. Service Conditions: IEEE C37.121, usual service conditions except for the following:
 - 1. Exposure to significant solar radiation.
 - 2. Altitudes above 3300 feet (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.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Electric Corporation; Power Distribution Products Division.
 - 2. Cooper Industries; Cooper Power Systems Division.
 - 3. Cutler-Hammer.
 - 4. GE Electrical Distribution & Control.
 - 5. Siemens Energy & Automation, Inc.
 - 6. Square D; Schneider Electric.
 - 7. Virginia Transformer Corp.

2.2 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

- A. Description: ANSI C57.12.13, ANSI C57.12.26, IEEE C57.12.00, IEEE C57.12.22, pad-mounted, 2-winding transformers. Stainless-steel tank base.
- B. Primary voltage to be 34.5 k volts, 3 phase, 3 wire.
- C. Secondary voltage to be 480/277 volts, 3 phase, 4 wire.
- D. The pad-mounted, compartmental-type transformer shall consist of the transformer tank with high- and low-voltage cable terminating compartment. The transformer tank and compartment shall be assembled as an integral unit for mounting on a pad. There shall be no exposed screws, bolts, or other fastening devices which are externally removable. There shall be no openings through which foreign objects such as sticks, rods, or wires might contact live parts. There shall be means for padlocking the compartment door(s). The construction shall limit the entry of water (other than flood water) into the compartment so as not to impair the operation of the transformer.
- E. Full-height, air-filled incoming and outgoing terminal compartments with hinged doors shall be located side-by-side separated by a steel barrier, with the incoming compartment on the left. The high-voltage (incoming) compartment will be accessible only after the door to the low-voltage (ougoing) compartment has been opened. To facilitate making connections and permit cable pulling, the doors and compartment hood shall be removable. Removable door sill on compartments shall be provided to permit rolling or skidding of unit into place over conduit studs in foundation.

- F. The compartments will have hinged doors equipped for latching in the open position. The high-voltage compartment door will have a fastening device which is accessible only through the low-voltage compartment.
- G. The hinge assemblies shall be made of corrosion-resistant material. Stainless-steel hinge pins of 3/8 inch minimum diameter will be provided.
- H. Both compartment doors must be capable of being secured with a single padlock having a maximum ½ inch diameter shackle.
- I. Lifting provisions in accordance with ANSI Standards shall be provided.
- J. Jacking and rolling provisions shall be provided.
- K. Low-voltage bushings shall be tinned, spade-type with 9/16 inch holes on 1 ¾ inch centers in accordance with the Latest Revisions of ANSI.
- L. Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300°C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
- M. Insulation Temperature Rise: 55°C when operated at rated kVA output in a 40°C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30°C over 24 hours with a maximum ambient temperature of 40°C without loss of service life expectancy.
- N. Basic Impulse Level: 200 kV.
- O. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- P. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed circuits.
- Q. High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
 - 1. Bushing-Well Inserts: One for each high-voltage bushing well.
 - 2. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
 - 3. Parking Stands: One for each high-voltage bushing well.
 - 4. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
- R. Accessories:
 - 1. Drain Valve: 1 inch (25 mm), with sampling device.
 - 2. Dial-type thermometer.
 - 3. Liquid-level gage.
 - 4. Pressure-vacuum gage.
 - 5. Pressure Relief Device: Self-sealing with an indicator.
 - 6. Mounting provisions for low-voltage current transformers.
 - 7. Mounting provisions for low-voltage potential transformers.
 - 8. Busway terminal connection at low-voltage compartment.
 - 9. Alarm contacts for gages and thermometer listed above.

10. Hinge assemblies shall be made of corrosion-resistant material. Stainless steel hinge pins of 3/8" minimum will be provided.

2.3 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Identification."
- B. The instruction nameplate is to be located in the low-voltage portion of the compartment and shall be readable with cables in place. Where the nameplate is mounted on a removeable part, the manufacturer's name and transformer serial number shall be permanently affixed to a non-removable part.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to [ANSI C57.12.50] [ANSI C57.12.51] [IEEE C57.12.90] [IEEE C57.12.91].
- B. Factory Tests: Perform the following factory-certified tests on each transformer:
 1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
 2. Ratios on rated-voltage connection and on tap extreme connections.
 3. Polarity and phase relation on rated-voltage connection.
 4. No-load loss at rated voltage on rated-voltage connection.
 5. Excitation current at rated voltage on rated-voltage connection.
 6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
 7. Applied potential.
 8. Induced potential.
 9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
 - a. Temperature test is not required if record of 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 conditions for compliance with requirements for medium-voltage transformers.
- 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 concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 16 Section "Grounding" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION

A. Install transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Section "Supports and Anchors."
2. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
3. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"
4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Identification."

3.4 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding."

B. Connect wiring according to Division 16 Section "Wires and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

D. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

- F. Test Reports: Prepare written reports to record the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:
1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. 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 nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
 4. Report: Prepare written report covering monitoring and corrective actions performed.
- B. Infrared Scanning: Perform as specified in Division 16 Section "Medium-Voltage Switchgear."

END OF SECTION 16435

PART I - GENERAL1.01 SECTION INCLUDES

- A. Fusible switches.
- B. Non fusible switches.

1.02 REFERENCES

- A. Materials and workmanship shall conform to the latest issue of all industry standards, publications. Or regulations referenced in this section and with the following references as applicable. Refer to Section 16010 for listing of issuing organizations or agencies.
 - 1. NECA - Standard of Installation (published by the National electrical Contractors Association).
 - 2. NEMA FU1 - Low Voltage Cartridge Fuses.
 - 3. NEMA KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 - 4. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (published by the International Electrical Testing Association).
 - 5. NFPA 70 - National Electrical Code

1.03 SUBMITTALS FOR REVIEW

- A. Section 16010: Procedures for Submittals
- B. Product Data: Provide switch ratings and enclosure dimensions.

1.04 SUBMITTALS FOR CLOSEOUT

- A. Record actual locations of enclosed switches in project record documents.

1.05 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART II - PRODUCTS2.01 MANUFACTURERS

- A. Cutler Hammer
- B. General Electric
- C. Square D
- D. Siemens

2.02 FUSIBLE SWITCH ASSEMBLIES

- A. Description: NEMA KS 1, Type HD, enclosed load interrupter knife switch. Handle lockable in OFF position.
- B. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses.

2.03 NONFUSIBLE SWITCH ASSEMBLIES

- A. Description: NEMA KS 1, Type HD, enclosed load interrupter knife switch. Handle lockable in OFF position.

2.04 ENCLOSURES

- A. Fabrication: NEMA KS 1.
1. Interior Dry Locations: Type 1.
 2. Exterior Locations: Type 3R.

PART III - EXECUTION**3.01 INSTALLATION**

- A. Install in accordance with NECA "Standard of Installation".
- B. Install fuses in fusible disconnect switches.
- C. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.02 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.5

END OF SECTION 16441

PART I - GENERAL1.01 WORK INCLUDED

- A. Dry Type Transformers.

1.02 REFERENCES

- A. ANSI/NEMA ST 20 -Dry Type Transformers for General Applications.

1.03 SUBMITTALS

- A. Submit product data under provisions of Section 01300.
- B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, loss data, efficiency at 25%, 50%, 75%, and 100% rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Store and protect under provisions of Section 01600.
- B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust.
- C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow, if handled in inclement weather.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS - DRY TYPE TRANSFORMERS

- A. Acceptable manufacturers are as follows:

- 1. Square D
- 2. General Electric
- 3. Eaton- Cutler Hammer
- 4. Acme

2.02 DRY TYPE ISOLATION TRANSFORMERS

- A. Dry Type Transformers: ANSI/NEMA ST 20; factory-assembled, air-cooled, dry type transformers; ratings as shown on Drawings.

- B. Insulation system and average winding temperature rise for rated kVA as follows:

<u>kVA Rating</u>	<u>Insulation Class</u>	<u>Temperature Rise (° C)</u>
1 - 15	185	115
30 - 500	220	150

- C. Case temperature shall not exceed 35° C rise above ambient at its warmest point.
- D. Winding Taps, Transformers Less than 15 kVA: Two 5% below rated voltage, full capacity taps on primary winding.

- E. Winding Taps, Transformers - 15 kVA and Larger: ANSI/NEMA ST 20.
- F. Sound Levels: ANSI/NEMA ST 20.
- G. Basic Impulse Level: 10 kV for transformers less than 300 kVA, 30 kV for transformers 300 kVA and larger.
- H. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- I. Mounting: Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be suitable for floor or trapeze mounting.
- J. Coil Conductors: Continuous windings with terminations brazed or welded.
- K. Enclosure: ANSI/NEMA ST 20 - provide lifting eyes or brackets.
- L. Isolate core and coil from enclosure using vibration absorbing mounts.
- M. Nameplate: Include transformer connection data and overload capacity, based on rated allowable temperature rise.

PART III - EXECUTION

3.01 INSTALLATION

- A. Set transformer plumb and level. Dry type transformers rated 15 kVA or less shall be wall-mounted using suitable support brackets; larger sizes shall be floor-mounted or suspended from the structure above using suitable support hangers when clearance and serviceability allow.
- B. Use flexible conduit 2' (0.6 m) minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- C. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.
- D. Provide seismic restraints where required by jurisdictional authorities.
- E. Dry type transformer shall be set with a minimum of 3" spacing to all walls.

3.02 FIELD QUALITY CONTROL

- A. Check for damage and tight connections prior to energizing transformer.
- B. Measure primary and secondary voltages; make appropriate tap adjustments.

END OF SECTION 16461

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED**

- A. Resistive Load Banks: Quantity of one (1) 2000 kW unit.
- B. Automatic controls.

1.02 REFERENCES

- A. NEMA: Requirements for Outdoor Weatherproof Construction

1.03 SUBMITTALS

- A. Submit product data under provisions of Section 01300.
- B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and kW ratings and characteristics, configurations, insulation system type, and rated temperature rise.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Store and protect under provisions of Section 01600.
- B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust.
- C. Handle load banks using only lifting eyes and brackets provided for that purpose. Protect units until ready for installation.

1.05 WARRANTY

- A. The manufacturer shall warrant the equipment against defects in materials and workmanship for a period of one year from date of shipment. In addition, the load resistors shall have an extended warranty period of three years.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Acceptable manufacturers are as follows:

- 1. Avtron
- 2. Loadtec
- 3. Simplex

2.02 GENERAL

- A. The load bank shall be a complete system with all necessary pilot and power controls, wiring, and devices to provide a functional system for the use intended. The only additional wiring shall be site required electrical wiring to the power sources and interconnections to the control panels.

2.03 APPLICATION

- A. The load bank shall have the capability to load several individual power sources, the individual UPS systems, and the generator systems.

- B. The load bank shall have the capability to be controlled from one location.
- C. The designated source connected to the load bank shall be controlled by the output circuit breakers at the source.

2.04 CONFIGURATION

- A. The load bank system shall consist of two separate subsystems.
 - 1. The load enclosure containing the load resistors, cooling fan, and power control devices, including the power source switching.
 - 2. A control panel containing the required pilot controls and indicators.

2.05 RATINGS

- A. Load: 2000 kW @ 480 V, 3 Phase, 3 Wire, 60 Hertz, 1.0 Power Factor
- B. Load Steps: Incrementally progressive at 50 kW, seven load steps of: two (2) 50, two (2) 100, one (1) 200, and two (2) 250, and two (2) 1000 kW.
- C. Duty Cycle: Continuous at rated ambient.
- D. Ambient:
 - 1. Temperature: -20° F to 120° F
 - 2. Altitude: 2500 ft.
 - 3. Relative Humidity: 0 to 100%
- E. Tolerances:
 - 1. Overall load and per load step: +/-5% of nominal rating
 - 2. Phase-to-Phase of the total load and per load step: +/- 2% of mean phase.
 - 3. Load bank shall be rated 65,000 KAIC minimum.

2.06 ENCLOSURES

- A. Load Enclosure:
 - 1. The enclosure shall be suitable for outdoor installation with bolt-down provisions for permanent mounting to a concrete pad or other adequate support structure.
 - 2. The enclosure shall be provided with overhead lifting and captive fork lifting tubes for handling during installation.
 - 3. The enclosure shall be configured to isolate the cooling air flow through the load chamber, containing the load resistor and cooling fan, from the control section containing the power control and distribution components.
 - 4. The control section shall be NEMA3/IP55 rated with hinged and gasketed access doors. The load section shall be NEMA 3R/IP24 with fixed louvers and guards on the intake and exhaust openings.
 - 5. The enclosure shall have adequate space to install the conduits from the power source. Conduit installation provisions shall meet the requirements of the latest revision of the National Electrical Code/NFPA 70, Article 373.
 - 6. The basic enclosure shall be fabricated of electroplated galvanized steel. The intake and exhaust louvers and guards shall be fabricated of stainless steel.
 - 7. The air flow through the unit shall be horizontal and constructed to prevent recirculation of the cooling air.
- B. Control Enclosure

1. The control enclosure shall be suitable for indoor, wall-mounting.
2. The enclosure shall be NEMA 12/IP52 rated with hinged and gasketed accesses door.
3. All control components shall be subpanel mounted with pilot controls and indicators mounted and wired to the exterior door.

C. Paint

1. All metal surfaces shall be properly prepared, primed, and painted. There shall be no raw surfaces, except for stainless steel or panels that have special platings after fabrication.
2. All surfaces to be painted shall be prepared in accordance with SSPC Surface Preparation Standard SP1.
3. All surfaces to be painted shall be primed using rust inhibiting etching primer intended for use on galvanized steel and applied in accordance with the manufacturer's recommendations.
4. All primed surfaces shall be finish-coated using a polyurethane enamel paint applied in accordance with the manufacturer's recommendations. Finish paint color shall be ASA 61 gray.

2.07 LOAD RESISTORS

- A. The load resistors shall be open wire wound type that are continuously supported the length of the resistor structure. If the resistor alloy should fail, the resistor material shall be held captive to prevent contact with any surrounding resistors or ground.
- B. The resistor's continuous support shall consist of segmented ceramic tubes assembled on stainless steel rods with fastenings provided to compensate for thermal expansion of the ceramic tubes.
- C. The resistors shall be fabricated of a corrosion-resistant chromium alloy that has a minimum continuous operating temperature of 1900° F.
- D. The resistor shall not operate at any point in excess of 67% of the alloy's maximum continuous operating temperature at all ambient extremes.
- E. The resistors shall be installed in multiple field removable trays that are small enough to facilitate easy maintenance. Each tray shall be individually removable without affecting any adjacent tray.
- F. The resistor terminals shall be brought to the exterior of the tray through high grade electrical ceramics. No plastic or polyester glass laminates shall be used in any part of the resistor assembly.
- G. The resistor terminations shall be formed from the alloy material or have fabricated terminals of the similar material welded to the alloy.
- H. The resistors shall not require a cool down period. Normal shutdown or failure of the cooling fan during operation of the resistors shall not shorten their life expectancy.

2.08 COOLING SYSTEM

- A. The load bank shall be forced air cooled.
- B. The cooling fan (s) shall be one piece cast aluminum and direct driven by a three phase, TEFC, 1800 RPM induction motor.
- C. The motor shall be rated at the maximum brake horsepower of the fan propeller for the applied static pressure load.

2.09 COOLING SYSTEM

- A. Cooling Failure:

1. A cooling failure circuit shall be provided to monitor the cooling system operation and to disconnect the load steps before damage can occur.
2. An air flow switch for each cooling fan shall be provided to monitor fan operation and flow direction.
3. A temperature switch at the load chamber exhaust of each cooling fan shall be provided to monitor for excessive exhaust temperature.

B. Fuses:

1. Each individual load section/load step shall be fused to protect its wiring and control devices.
2. Fuses shall be provided for protection of the control power transformer and wiring.

C. Cooling Fan:

1. The cooling fan shall be protected by a thermal magnetic molded case circuit breaker in combination with a contactor and thermal overload relay.

2.10 WIRING AND BUS

A. Wiring:

1. The load and control wiring shall have a minimum rating of 105° C.
2. The wire shall be sized at 125% of the maximum ampacity at rated ambient.
3. Control wiring shall have sleeve type wire numbers that are identified on the wiring diagrams.
4. External interconnect wiring shall be terminated at barrier terminal blocks.

B. Load Bus:

1. A main load bus shall be provided for each power source.
2. Each main bus shall run the length of the control section of the load enclosure so the bus mounted fuses require only short jumpers to the load contactors.
3. The load bus shall be silver plated copper and sized for the temperature rise at the full ampacity rating of the load. The load bus shall have a maximum temperature rise of 35° C.
4. Mechanical lugs shall be provided at the end of each bus to connect its respective power source. The number and size of the lugs shall accept the number and size of cables indicated on the one line drawing.
5. Mechanical lug (s) shall be provided to accept code-required equipment grounding conductors.

2.11 POWER CONTROLS

- A. The load shall be controlled by resistive-rated contactors capable of continuous and cycling operations.
- B. All control devices shall be clearly and permanently labeled to coordinate with their drawing function designations.

2.12 PILOT CONTROLS

- A. All required control circuitry shall be supplied to achieve the functions described for the control switches and indicators.
- B. All exterior control devices shall be permanently and clearly marked for function and operational settings. All control devices shall be clearly and permanently labeled on the interior of the enclosure to coordinate with their drawing function designations.
- C. All control switches and indicators shall be industrial oil tight type.
- D. Each control panel shall have the following control switches:

1. Control Mode switch to select the operational mode of the system. The switch shall be three position for functions of Auto-Off-Manual. In the Auto position, the load bank shall automatically disconnect in the event of utility power failure or other cause that requires the power source to service its normal loads. In the Off position, the load bank shall be locked out and all circuits reset. In the Manual position, the system shall operate the same as in the Auto position, except the load bank does not disconnect from the loss of utility power.
 2. Fan Control/Cooling Failure Reset switch to control the cooling fan (s) and reset any cooling failure alarms. The switch shall be three position for functions of Off-On-Reset (momentary).
 3. Master Load switch that allows simultaneous control of preselected load steps.
 4. Individual Load Step switches to control each load step.
- E. Each control panel shall have the following indicators:
1. Fan Running indicator with green lens to annunciate if the fan (s) is running.
 2. Cooling Failure indicator with red lens to annunciate a fault condition.
 3. Individual Load Step indicators with blue lenses to annunciate the energization of each load step.
- F. Control panel shall have circuitry provisions to interface to the automatic transfer switch circuitry that will disconnect the load bank in the event of utility power failure or other cause that requires the power source to service its normal loads.
- 2.13 CONTROL POWER
- A. Control Circuits:
1. Control power shall be derived from the power source to be tested via a control power transformer.
 2. Control power shall be 120 VAC, 1 phase, 60 Hz.
- B. Fan Power:
1. Fan power shall be derived from the power source selected to be loaded. The fan power shall be 3 phase and match the voltage and frequency of the power source.

PART III - EXECUTION

3.01 INSTALLATION

- A. Install the load enclosure and control panel in accordance with the manufacturer's drawings and instructions in the location detailed on the site plan.
- B. Provide and install power and control wiring in accordance with the manufacturer's drawings and instructions in the location detailed on the site plan.
- C. Set load bank plumb and level; attach securely to concrete pad.
- D. Make all connections to load bank for power and control wiring as required.
- E. Provide seismic restraints where required by jurisdictional authorities.

3.02 FIELD QUALITY CONTROL

- A. Check for damage and tight connections prior to energizing transformer.
- B. Measure primary and secondary voltages; make appropriate adjustments.

3.03 FINAL ACCEPTANCE

- A. The load bank system shall be adjusted and inspected in accordance with the manufacturer's initial operation instructions.
- B. The entire system shall be operated to demonstrate the function of each control panel and the accuracy of the applied load.
- C. Each failure sensor shall be operated to demonstrate the operation of the safety system.

3.04 OPERATIONS AND MAINTENANCE MANUALS

- A. Two sets of final as-built manuals containing the same information as required for submittal shall be shipped with the system.

END OF SECTION 16471

PART I - GENERAL1.01 WORK INCLUDED

- A. Furnish and install all lamps listed in the lighting fixture schedule on the drawing.

1.02 RELATED WORK

- A. Section 16510: Interior Lighting.

1.03 SUBMITTALS

- A. Submit manufacturer's installation instructions.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. The acceptable manufacturers for lamps are as follows:

1. Sylvania
2. General Electric
3. Philips

2.02 LAMPS

- A. For all lamp types, see lighting fixture schedule on drawing.

END OF SECTION 16501

PART I - GENERAL1.01 WORK INCLUDED

- A. This Section includes supply and installation of luminaries, supports, and accessories.

1.02 RELATED WORK

- A. Section 16120: Wires and Cables
B. Section 16190: Supporting Devices
C. Section 16501: Lamps

1.03 COORDINATION

- A. Confirm compatibility and interface of other materials, luminaire and ceiling system. Report discrepancies to the Engineer/Architect, and defer ordering until clarified.
- B. Coordinate with Division 15 to avoid conflicts between luminaires, supports, fittings, and mechanical equipment.

1.04 EQUIPMENT STANDARDS

- A. Request for use of lighting fixtures other than those listed in the fixture schedule shall be submitted in writing. Request for fixture substitution shall be accompanied by construction specifications, photometric test data, including foot lambert readings, and complete dimensions.
- B. Verify fixture numbers, before placing order, to assure that fixtures will be furnished with proper frames, fittings, and devices for installation in the ceiling system that is to be installed.
- C. All fixtures of the same type shall be of one manufacturer and of identical finish and appearance.
- D. All fixtures shall be UL listed and labeled under one or more of the following standards:
1. UL 1570: Fluorescent Lighting Fixtures.
 2. UL 1571: Incandescent Lighting Fixtures.
 3. UL 1572: High Intensity Discharge Lighting Fixtures.
 4. UL 1574: Standard for Track Lighting Systems.
 5. UL 677: Underwater Lighting Fixtures.

PART II - PRODUCTS2.01 LIGHTING FIXTURES

- A. Lighting fixtures shall be selected from those fixtures included in the fixture schedule not only by catalog number, but also with consideration to mounting, number and types of lamps, and reference notes all as contained in the schedule.
- B. Fixtures shall be complete with lamps of the type noted in schedules and shall have metal parts, glassware, plastic diffusers, etc., free from scratches, cracks, and other defects. Any items damaged during shipment, handling, or installation shall be replaced without expense to the Owner.
- C. Plaster frames, furnished with fixtures, shall be provided for all fixtures, flush-mounted in plaster, stucco, or drywall ceiling.
- D. Each fixture shall have a continuous light-seal gasket seated in such manner as to prevent any light leak through any portion or around any edge of the trim frame.

- E. Diffusers shall be as specified under each respective fixture and shall be framed in a hinged, continuous assembly which shall be removable without tools. There shall be a gasketed seat between the frame and fixture body to prevent light leaks. Diffusers for fluorescent fixtures shall be 100% pure virgin acrylic, with minimum thickness of 0.125".
- F. Each lay-in fluorescent fixture shall be provided with four T-bar safety clips. Clips shall be screwed to the fixture body and support the fixture from the top of the T-bar. Snap clips shall not be acceptable. T-bar safety clips shall be similar to Lithonia #LATC.
- G. Acceptable equal fixture manufacturers: Lithonia, Columbia, or Mercury.

2.02 LAMPS

- A. Fluorescent lamps shall be energy saving type, General Electric or equal by Philips lighting company or Sylvania, unless shown differently on the drawings.
- B. Incandescent lamps shall be 130 volt type, unless shown differently on the drawings.
- C. HID lamps shall be clear type, unless shown differently on the drawings. Verify proper lamp type with lighting fixture manufacturer.

2.03 BALLASTS

- A. Fluorescent ballasts shall be electronic, high efficiency ballast with total harmonic, distortion not to exceed 10%. Ballast shall be U.L. listed and CBM certified.
- B. Accepted equal manufacturers shall be Advance, Magnetek and General Electric.
- C. Compact fluorescent ballasts shall be high power factor, including all twin tube and quad tube lamp types. Input wattage shall be clearly marked on the fixture. All compact fluorescent ballasts shall be UL listed.

2.04 PROTECTION

- A. Recessed incandescent fixtures shall have thermal protection as specified in NEC Article 410.

PART III - INSTALLATION

3.01 LIGHTING FIXTURES

- A. Fixtures shall be located in a manner coordinated with suspended acoustic ceiling pattern, and in accordance with patterns as shown on the architectural drawings.
- B. Recessed fluorescent fixtures shall be installed with 6'-0" flexible conduit connecting the fixture housing and the outlet box.
- C. Fluorescent fixtures, flush-mounted in exposed tee suspended acoustical tile ceilings shall be of the lay-in type which shall rest on and be supported by the main runners of the ceiling support system at each end with clips intended for that purpose.
- D. Fixtures shall be supported from structural members or from ceiling suspension members if such members are not smaller than 1½" channels or inverted tees. Fixture supports shall be standard bar hangers, or other approved method. In no case shall fixtures be supported directly from ceiling

- surfaces. Provide all structural steel members necessary for proper and secure support. Provide all yokes, saddles, etc., required.
- E. Surface-mounted fluorescent fixtures shall be supported by light-weight channel attached by tie straps to two members of the ceiling suspension system. Surface-mounted fixtures mounted on sheet rock or plaster ceilings or low density acoustical tile ceilings shall be mounted with metal spacers between fixture and ceiling.
 - F. Flush-mounted incandescent fixtures shall be mounted on fixture mounting bars, furnished with fixtures, attached to two adjacent ceiling support system members with nylon tie straps.
 - G. Surface and wall-mounted incandescent fixtures shall be mounted on fixture stud in outlet box. Studs shall be steel or malleable iron, all galvanized. In no case shall die cast studs be used.
 - H. Suspended fixtures shall be stem-mounted and shall be free to swing 20° in any direction. Ceiling swivels shall be of the ball aligner type. Chain suspension may be used only where specifically permitted on the drawings. Chain shall be heavy duty, nickel- or cadmium-plated, suitable for weight of specific fixtures.
 - I. For recessed incandescent, fluorescent, or HID fixtures installed in inaccessible ceiling locations, provide fixtures suitable for use in this application and UL listed as such. Manufacturer's literature stating "Suitable for use in inaccessible ceilings" shall accompany shop drawings.
 - J. Exit signs shall be provided with directional arrows as indicated on the drawings.

END OF SECTION 16510

PART I – GENERAL1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes exterior lighting units with luminaires, lamps, ballasts, poles/support structures, and accessories.
- B. Related Sections include the following:
 - 1. Section 16510 "Interior Room Lighting" and 16501 "Lamps" for interior fixtures, lamps, ballasts, emergency lighting units, and accessories; and drawings for exterior luminaires normally mounted on buildings.

1.03 DEFINITIONS

- A. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.
- B. Luminaire (Light Fixture): A complete lighting device consisting of lamp(s) and ballast(s), when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect lamps to power supply.

1.04 SUBMITTALS

- A. Product Data: For each type of lighting unit indicated, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - a. Materials and dimensions of luminaires and poles.
 - b. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data.
 - c. Certified results of laboratory tests for fixtures and lamps for photometric performance.
 - d. High-intensity-discharge luminaire ballasts.
- B. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.05 QUALITY ASSURANCE

- A. Luminaires and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use, location, and installation conditions by a testing agency acceptable to authorities having jurisdiction
- B. Comply with ANSI C2.
- C. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING OF POLES

- A. Package aluminum poles for shipping according to ASTM B 660.

- B. Store poles on decay-resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on fiberglass poles until just before pole installation. Handle poles with web fabric straps.
- D. Retain factory-applied pole wrappings on metal poles until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.07 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART II – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Exterior Lighting Unit Schedule located on Drawings.

2.02 LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect ballast when door opens.
- F. Exposed Hardware Material: Stainless steel.

- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.
- J. Photoelectric Relays: As follows:
 - 1. Contact Relays: Single throw, arranged to fail in the on position and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay.
 - 2. Relay Mounting: In luminaire housing.
- K. High-Intensity-Discharge Ballasts: Comply with ANSI C82.4. Constant wattage autotransformer or regulating high-power-factor type, unless otherwise indicated.
 - 1. Ballast Fuses: One in each ungrounded supply conductor. Voltage and current ratings as recommended by ballast manufacturer.
 - 2. Single-Lamp Ballasts: Minimum starting temperature of minus 40 deg C.
 - 3. Open-circuit operation will not reduce average life.
 - 4. High-Pressure Sodium Ballasts: Equip with a solid-state igniter/starter having an average life in pulsing mode of 10,000 hours at an igniter/starter case temperature of 90 deg C.
 - 5. Noise: Uniformly quiet operation, with a noise rating of B or better.
- L. Lamps: Comply with the standard of the ANSI C78 series that is applicable to each type of lamp. Provide luminaires with indicated lamps of designated type, characteristics, and wattage. Where a lamp is not indicated for a luminaire, provide medium wattage lamp recommended by manufacturer for luminaire.
 - 1. High Pressure Sodium Color Temperature: 2100 K, unless otherwise indicated.

2.03 LUMINAIRE SUPPORT COMPONENTS

- A. Description: Comply with AASHTO LTS-3 for pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
- B. Wind-Load Strength of Total Support Assembly: Adequate to carry support assembly plus luminaires at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mph (160 km/h) with a gust factor of 1.3. Support assembly includes pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.

Strength Analysis: For each pole type and luminaire combination, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- C. Finish: Match finish of pole/support structure for arm, bracket, and tenon mount materials.
- D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Will not cause galvanic action at contact points.
 2. Mountings: Correctly position luminaire to provide indicated light distribution.
 3. Anchor Bolts, Nuts, and Washers: Hot-dip galvanized after fabrication unless stainless-steel items are indicated.
 4. Anchor-Bolt Template: Plywood or steel.
- E. Pole/Support Structure Bases: Anchor type with hold-down or anchor bolts, leveling nuts, and bolt covers.
- F. Steel Poles: Tubing complying with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 20 feet in length with access handhole in pole wall.
- G. Aluminum Poles: Fabricated from seamless, extruded structural tube complying with ASTM B 429, 6063-T6 alloy with access handhole in pole wall.
1. Grounding Provisions for Metal Pole/Support Structure: Welded 1/2-inch threaded lug, accessible through handhole and listed for copper conductor connection.

2.04 FINISHES

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Aluminum: Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

PART III – EXECUTION

3.01 INSTALLATION

- A. Concrete Foundations: Construct according to Division 3 Section "Cast-in-Place Concrete."
1. Comply with details for reinforcement and for anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
 2. Finish for Parts Exposed to View: Trowel and rub smooth. Comply with Division 3 Section "Cast-in-Place Concrete" for exposed finish.
- B. Install poles as follows:
1. Use web fabric slings (not chain or cable) to raise and set poles.
 2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 3. Secure poles level, plumb, and square.
 4. Grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space.
 5. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- C. Luminaire Attachment: Fasten to indicated structural supports.
- D. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.

3.02 CONNECTIONS

A. Ground equipment.

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

3.03 FIELD QUALITY CONTROL

A. Inspect each installed unit for damage. Replace damaged units.

B. Advance Notice: Give dates and times for field tests.

C. Provide instruments to make and record test results.

D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:

1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
2. Check intensity and uniformity of illumination.
3. Check excessively noisy ballasts.

E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.

F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.04 CLEANING AND ADJUSTING

A. Clean units after installation. Use methods and materials recommended by manufacturer.

B. Adjust amiable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 16521

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 WORK INCLUDED**

- A. Provide four (4) Uninterruptible Power Systems (UPSs) each consisting of one (1) 750 kVA (675 kw) module feeding a 2500a parallel switchboard, shall be furnished to provide regulated alternating current (AC) power for a critical computer load with open vented (wet cell) batteries in racks for eight (8) minute back up of 675 kw per module. Each system shall be fully coordinated and compatible with electrical, environmental, and space conditions at the site, and be expandable with two (2) additional modules for the design capacity of 1620 kw (at 80% loading). Battery racks shall have a spill containment system as described in Section 2.05.C.
- B. The UPS shall consist of standard equipment and meet specified capacity requirements. The manufacturer shall base his proposal on the requirements of this specification and shall state any deviation from the specification in his proposal.
- C. Manufacturer shall design and furnish all materials and equipment. The UPS shall be complete as defined by the requirements of these specifications, and shall be designed for installation in the UPS room and for unattended operation.
- D. The UPS and all associated equipment shall be in accordance with applicable local codes and National Electrical Code, OSHA, and as approved by all inspection authorities having jurisdiction. All equipment or components shall be manufactured in accordance with applicable NEMA, ASA, IEC, and IEEE standards.
- E. The complete UPS, including the battery racks, is to be listed by UL and/or ETL. The system is also to meet the requirements of FCC Part 15, Sub Part J, Class A, and VDE 0871A for conducted and radiated electrical noise.
- F. Installation of the battery system shall be performed by a qualified battery maintenance contractor.
- G. UPS input filter shall be contactor controlled to be disconnected when load drops below 25%.
- H. System control cabinet per attached sketch 'SC'.
- I. The UPS shall be capable of communications via a site link module or equivalent Modbus protocol.
- J. The UPS module to accept top entry feed.
- K. Provide 600 kcmil lugs for battery disconnect switch.

1.02 SUBMITTALS

- A. The following drawings and information are to be submitted under the provisions of Section 01340.
 - 1. System configuration with single line diagrams. All circuit breakers shall be identified by location, frame size, trip rating, short circuit current rating, and manufacturer with type number.
 - 2. Functional relationship of various equipment including weights, dimensions, and heat dissipation of each unit.
 - 3. Detailed descriptions of equipment to be furnished, including all deviations and exceptions from these specifications. The supplier shall provide a specification "Compliance Matrix" for this purpose.
 - 4. Size and weight of individual shipping units to be handled by Contractor in the field.

5. Detailed layouts of all metering, alarm, and mimic panels. The metering sensing points are to be shown on the single line diagram.
- B. The following drawings and information are to be submitted 15 days prior to the delivery of the UPS.
 1. Detailed installation drawings including all terminal locations.
 2. Interconnect wiring diagrams showing all conduit runs and wiring with terminal numbers for each wire. External power, control and monitoring wiring shall be clearly shown.
- C. The following drawings and manuals are to be submitted to the Architect/Engineer for his approval to be presented to the Owner for his use.
 1. A complete set of as-built drawings.
 2. Three complete sets of instruction manuals shall be provided for the UPS. The manuals shall include a functional description of the equipment, safety precautions, instructions for step-by-step operating and maintenance procedures, including drawings and illustrations.

1.03 DEFINITION OF TERMS

- A. The term UPS, as used herein, shall denote 750 kVA rated UPS modules, operating in parallel, a static transfer switch, control and monitoring panels, and a battery system to provide continuous conditioned AC power to a critical load.
- B. "UPS Module Cabinet": A metal enclosure which contains the rectifier/charger, the inverter, the static transfer switch, the maintenance bypass switch, operator controls, and the internal control system required to provide specified AC power to a critical load.
- C. "Battery Rack": A metal rack which contains the open vented wet cell type battery sufficient enough to maintain UPS output per specification with a battery disconnect circuit breaker.
- D. "UPS Module": The rectifier/charger and inverter units which, under the supervision of the internal control system and external operator controls, provide specified AC power to a critical load.
- E. "Rectifier/Charger": The UPS component which contains the equipment and controls necessary to convert input AC power to regulate DC power required for input power to the inverter unit for battery charging.
- F. "Inverter": The UPS component which contains the equipment and controls necessary to convert DC power from the rectifier/charger or the battery to AC power required by the critical load.
- G. "Internal Control System": The signal processing circuits that regulate the power conversion processes, detect fault conditions, and control the sequence of operation of the UPS. This term may be shortened to "control system".
- H. "Operator Controls": The controls that are used by the operator to monitor and operate the UPS. They are to be located on the front of the UPS module cabinet exterior.
- I. "Static Transfer Switch": The device which automatically transfers the critical load without interruption to the static bypass line in the event an overload or degradation of the UPS/Inverters performance.
- J. "Static Bypass Line": The line that conducts unconditioned power to the critical load through the static transfer switch.
- K. "Maintenance Bypass Line": The line which conducts unconditioned power to the critical load during maintenance while electronically isolating the static transfer switch and UPS modules for maintenance purposes.

- L. "Input Power": Power provided by the electrical utility company or auxiliary generator that is connected to the input of the UPS.
- M. "Static Isolator": The device that isolates a UPS module from the critical bus in the event of a module failure.
- N. "UPS System Control Cabinet": That portion of the UPS containing that portion of the critical load bus common to the output of each UPS module, static transfer switch, system level metering and control functions. Cabinet shall have three (3) breakers sized for the ultimate final configuration of each system.

PART II - PRODUCT

2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are as follows:
 - 1. Liebert
 - 2. Powerware
 - 3. MGE
- B. Regulatory Requirements - The UPS will meet the requirements of the following standards:
 - 1. UL Listed under 1778, Standards for Uninterruptible Power Supply Equipment.
 - 2. FCC rules and regulations of Part 15, Subpart J, Class A.
 - 3. IEEE 587-1980/ANSI C62.41 1980 Standards for Surge Withstand ability.
 - 4. The UPS will be designed in accordance with the applicable sections of the documents published by:
 - a. National Fire Protection Association (NFPA)/National Electric Code (NEC)
 - b. National Electrical Manufacturer's Association (NEMA)
 - c. Occupational Safety & Health Administration (OSHA)

2.02 DESCRIPTION AND OPERATION

- A. The UPS System shall consist of rectifier/chargers, battery system, inverters, static transfer switch, synchronizing equipment, protective devices and accessories as specified herein. The UPS is to automatically affect continuity of electric power within specified tolerances to the critical load, without interruption, even with a failure or deterioration of the normal power supply. Continuity of electric power to the load shall be maintained for an emergency period with the UPS supplied by battery power up to the specified time or until restoration of the power supply.
- B. Normally, electric energy from the utility company power source shall be used to supply power to the rectifier/charger unit. The rectifier/charger shall be solid state and shall convert incoming AC power to DC power. The rectifier/charger output shall be fed into the solid state inverter. The inverter shall convert the DC power into AC power that shall supply the load. Upon failure of AC power, input power for the inverter shall automatically be supplied from the battery with no interruption to, or disturbances of, inverter output in excess of the limits of these specifications. At the same time, the UPS shall energize an alarm circuit and associated trouble indicators. When the AC power is restored, input power for the inverter and for recharging the battery shall be automatically be supplied from the rectifier/charger output without interruption or disturbances in excess of limits of these specifications. If the battery is exhausted before AC power returns, the UPS shall shutdown automatically.
- C. System Configuration:

1. This specification describes three phase, on-line, Multi-Module Parallel system (Non-Redundant) solid state uninterruptible power system with reverse transfer, hereafter referred to as the UPS. The UPS shall operate in conjunction with the building electrical system to provide power conditioning, back-up power protection and distribution for electronic equipment loads. The system shall consist of a system Static Switch Cabinet (SSC) and parallel connected UPS modules sized to support the load or the total load plus a specified number of redundant modules for enhanced reliability. Each UPS module shall contain a solid state Inverter, rectifier charger, and assembled battery racks and parallel control circuitry as described herein. The SSC shall contain the system static switch and bypass control circuitry.
 - a. Components:
 1. Battery
 2. Rectifier/charger to maintain battery charge and to provide input to Inverter when utility power is available.
 3. Inverter to provide power to load during normal operation.
 4. Static Switch Cabinet to transfer system load automatically and without disturbance between Inverter and utility power.
 - b. If the load is less than the installed number of modules, failure of one of the modules shall cause that module to be disconnected from the critical load by its static isolator and the remaining module (s) shall continue to carry the load in off line (non-redundant) operation. Upon repair of the module, it shall be reconnected to the critical load to resume redundant operation. Any module shall also be capable of being taken off the critical load manually for maintenance without disturbing the critical load bus. When one module is off-line, failure of a second module shall cause the load to be transferred automatically and uninterrupted to the bypass line by the use of the static transfer switch.
 1. The UPS is to provide two processed paths to the critical load as follows:
 - a. UPS inverter output
 - b. Static bypass line
 2. Normally, the UPS module will provide conditioned power to the load. If a UPS module should malfunction, the module automatically shuts down and alarms. A maintenance bypass line is to be provided to bypass the UPS module and static transfer switch to maintain the load while the UPS module is shutdown for maintenance. The maintenance bypass shall provide uninterrupted power to the critical load.
 3. The system is to contain open vented, wet cell battery systems in racks located remotely from the UPS modules.
- O. Design - The UPS system shall consist of like rated UPS modules connected in a parallel arrangement through the Static Switch Cabinet. The UPS shall be designated to operate as on-line reverse transfer system in the following modes:
 1. Normal: The Inverter shall continuously supply power to the critical load. The rectifier/battery charger shall derive power from the utility AC source and supply DC power to the Inverter while simultaneously floats charging the battery.
 2. Parallel Operation: Each UPS module shall support an equal share of the total load during normal, emergency, or recharge operation. Each UPS module will automatically disconnect and isolate from the system load in the event of a module failure, with no interruption of the critical load. (For a redundant parallel system, the remaining UPS modules will stay on line and continue to support the critical load.) (For a non-redundant system, the remaining UPS modules will support the critical load via system transfer to bypass.
 3. Emergency: Upon failure of the utility AC power source, the critical load shall be supplied by the Inverter, which, without any switching, shall obtain its power from the battery.
 4. Recharge: Upon restoration of the utility AC power source (prior to complete battery discharge), the rectifier/battery charger shall power the Inverter and simultaneously recharge the battery.
 5. Bypass Mode: The static bypass transfer switch shall be used to transfer the load to the bypass without interruption to the critical load. This shall be accomplished by turning the Inverter off. Automatic re-transfer or forward transfer of the load shall be accomplished by turning the Inverter on.

6. Maintenance Bypass/Test Mode: Each UPS module shall be equipped with a maintenance isolation switch to isolate the UPS module for maintenance. In parallel redundant configuration this shall allow UPS module to be shut down while the remaining UPS modules support the critical load.

2.03 UPS REQUIREMENTS

A. Rating

1. The UPS shall be sized to provide a minimum of 750 kVA and a minimum of 675 kW output.
2. The load voltage and bypass line voltage will be 480 VAC, three phase, 3 wire. The utility input voltage will be 480 VAC, three phase, 3 wire.
3. The UPS battery is to have a capacity to support a load of 675kW for a minimum period of 8 minutes at a temperature of 25° C. The battery is to provide 100% of the specified capacity at initial start-up. The battery racks shall have Seismic Zone construction.

B. Electrical Characteristics

1. Input
 - a. Voltage Range: + 10%, -15%
 - b. Frequency Range: $\pm 5\%$
 - c. Power Walk-in: 20% to 100% of full rated load over 15 seconds, or 2 seconds, switch selectable.
 - d. Magnetizing Sub-cycle Inrush: Six times normal full load input current maximum.
 - e. Power Factor: Not less than 0.9 lagging at full load.
 - f. Current Limit:
 1. 125% of normal input full load current if the load is connected to the UPS module or to the bypass line by the static transfer switch.
 2. If the load is connected to the maintenance bypass line, the input current limit to the UPS module is to automatically reduce to 25% of normal full load input current.
 - g. Protection: Meet NEC requirements. Single phase protection, wrong phase rotation protection.
 - h. Current Harmonics at Full Load: 7% THD maximum, with optional input filter.
 - i. Voltage Transient Protection: Meet the requirements of IEEE 587 at 4000V peak. Up to 150% line voltage for 1/2 cycle.
 - j. Phase Rotation: A leads B leads C.
 - k. Input Circuit Breaker sized at 1600 amps and rated 150,000 kaic minimum
2. DC Bus
 - a. Voltage Range

	<u>Battery Voltage in Volts per Cell</u>	
	<u>Maximum</u>	<u>Minimum</u>
Total Range	2.35	1.67
Float	2.27	2.
Equalize (1.21 Sg)	2.38	2.33
Low battery shutdown		1.60
Maintain full output AC voltage regulation	2.35	1.67
Overvoltage shutdown	2.40	
 - b. RMS Voltage Ripple: 2% with battery disconnected
 - c. Protection:
 1. External battery CB and internal disconnect.
 2. At low battery shutdown voltage, the battery CB will trip open.
 3. With battery disconnect CB open, the battery is to be ungrounded.
3. Output

- a. Steady state voltage regulation for no load to full load and minimum to maximum DC voltages to be $\pm 1\%$ for balanced load and $\pm 2\%$ for 50% unbalanced load and $\pm 5\%$ for 100% unbalanced load.
- b. Voltage Adjustment Range: $\pm 5\%$ manually.
- c. Frequency:
 1. Free Running Regulation for all loads, DC voltages and temperature conditions to be 0.1%
 2. Free Running Stability: $\pm 0.1\%$ in 24 hours, $\pm 1\%$ in 6 months
 3. Line Sync Range Selections: ± 2 , ± 1 , or ± 0.25 Hz switch selectable
 4. Maximum Rate of Change: 0.1 Hz per second
- d. Phase Displacement is $120^\circ \pm 1^\circ$ for balanced loads and $120^\circ \pm 3^\circ$ for 50% unbalanced loads.
- e. Voltage Unbalance:
 1. Balanced Load: All 3 line-to-line voltages within $\pm 1\%$
 2. 20% Unbalanced Load: All 3 line-to-line voltages within $\pm 1\%$
 3. 50% Unbalanced Load: All 3 line-to-line voltages within $\pm 2\%$
 4. 100 % Unbalanced Load (Single phase line-to-neutral load including phase controlled loads creating 3rd, 5th, and 7th harmonics): All 3 line-to-line voltages within $\pm 5\%$
- f. Voltage Transients:
 1. $\pm 7\%$ for 100% step load change
 2. $\pm 5\%$ for 50% step load change
 3. $\pm 1\%$ for loss or return of AC input power
 4. $\pm 4\%$ for manual transfer at full load.
- g. Voltage Transient Recovery Time to within 1% of output voltage rating within 50 milliseconds.
- h. Load Power Factor Range: 1.0 to 0.8 lagging
- i. Harmonic Voltage Distortion: Maximum 5% total, maximum 3% any single harmonic for non-linear loads at UPS rating without KVA/KW derating.
- j. Overloads supported by the UPS module at full regulated voltage are as follows:
 1. 150% of full load for 30 seconds.
 2. 125% of full load for 10 minutes.
 3. 115% of full load for 1 hour.
 4. Overload beyond these limits shall cause the load to be transferred to the static bypass line. Automatic retransfer to the UPS module shall occur once the overload is removed.
 5. Current limit - 150% full load current.
- k. Static Transfer Switch
 1. 1000% of full load for 1 cycle.
 2. 150% of full load for 30 seconds.
 3. 125% of full load for 10 minutes.
- l. Fault Clearing: Sub-cycle current of at least 300%.
4. Environmental Conditions
 - a. The UPS shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.
 1. Operating ambient temperature should be 0°C to 40°C for UPS Module and $25^\circ\text{C} \pm 5^\circ\text{C}$ for Battery.
 2. Non-operating and storage ambient temperature for the UPS Module should be -20°C to 70°C .
 3. Relative humidity 0% to 95% for temperatures in the operating range without condensation.
 4. Barometric Pressure
 - a. Operating - From sea level to 2,000 meters above.
 - b. Non-operating and storage - From sea level to 12,000 meters.

5. Audible Noise: Noise generated by the UPS under any condition of normal operation shall not exceed the allowable sound pressure level of 72 dba measured at 2 meters from the nearest surface of the cabinet.

2.04 UPS MODULE CABINET

- A. Each UPS module cabinet shall consist of a rectifier/charger, a three-phase inverter unit, with their associated transformers, logic, synchronizing equipment, protective devices, and accessories as required for proper operation. Each module cabinet shall be built to accept top entrance raceway feeders, as shown on drawing.

B. Rectifier/Charger Unit

1. The rectifier/charger unit shall be solid state and shall provide direct current to the inverter unit and for battery charging.
2. A dry type power transformer shall be used for the rectifier unit. It shall be copper wiring exclusively and have one 5% tap below rated voltage. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation class of material when operating full load at maximum ambient temperature of the transformer location within the rectifier/charger unit.
3. An input AC filter shall be incorporated into the rectifier/charger unit. The filter is not to be add-on in front of the rectifier/charger. This filter is to reduce the current harmonics feedback into the input AC line to no more than 7%. The filter is to also improve the input power factor so that it is no more lagging than 0.9.
4. The rectifier/charger unit shall provide for input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. This current limit shall be in effect no matter whether the load is connected to the UPS module or the static transfer switch. That is, if the static transfer switch is supplying full rated load, then the rectifier/charger must limit the battery recharging to 25%. Furthermore, if the load is connected to the maintenance bypass line, the rectifier/charger input current must automatically reduce to 25%.
5. The rectifier/charger unit shall provide features whereby when the AC power is returned after the UPS has been operating on battery power or has been de-energized, the total initial power requirement at the input terminals will not exceed 20% of rated load, and the power will gradually increase to 100% of full rating over the 15-second time interval. The unit shall be provided with an internal switch so that the power walk-in time can be changed from 15 seconds to 2 seconds.
6. Power semiconductors in the rectifier/charger unit shall have an output filter to minimize ripple current into the battery. Under no conditions shall ripple current into the battery exceed 2% RMS. The filter shall be adequate to insure that the DC output of the rectifier/charger will meet the input requirements of the inverter. UPS module is to have the capability of having the inverter operated from the rectifier/charger with battery disconnected.
7. In addition to supplying power to the load, the rectifier/charger shall be capable of recharging the battery as specified herein. The charging rate shall be sufficient to restore the battery from discharge to 95% charge within ten (10) times the discharge time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.
8. There shall be DC overvoltage protection so that if the DC voltage rises to the pre-set limit, the UPS module is to shutdown automatically and the load is to be transferred to the static bypass line uninterrupted.
9. To prevent battery damage from over discharging at light load, the rectifier/charger is to automatically raise the shutdown voltage set point as the load is reduced. The shutdown set point is to increase linearly from minimum to 1.75 volts per cell as the discharge time increases from 15 minutes to one hour.

C. Inverter Unit

1. The UPS output shall be derived from a Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics while

- operating over the battery voltage range. The inverter assembly shall be constructed of modular rack out assemblies to facilitate maintenance.
2. A dry type power transformer of the isolated winding type shall be used for the output of the inverter unit. It shall be copper wiring exclusively. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer location within the inverter unit.
 3. The output frequency of the inverter shall be controlled by an oscillator. The oscillator shall be temperature compensated and be adjustable $\pm 5\%$ of rated frequency. The oscillator shall hold the inverter output frequency to $\pm 0.1\%$ not to exceed $\pm 0.1\%$ during a 24 hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed $\pm 0.1\%$ from the rated frequency.
 4. The inverter output shall stay synchronized with the static bypass line provided the static bypass line remains within ± 3 Hz of the nominal frequency. If the line frequency goes outside these limits, the inverter is to break sync with the line and run on its internal frequency. When the line frequency returns, within limits, the inverter output is to automatically re-synchronize with the line. The rate of change of frequency is not to exceed ± 0.1 Hz per second. The unit shall be provided with an internal switch so that the synchronizing frequency range can be changed from ± 3 Hz to ± 1 Hz or to ± 0.5 Hz.
 5. The inverter shall be able to sustain an overload across its output terminals up to 150% load while supplying any load within its rating, without reducing the output voltage. Loads greater than 150% shall be transferred to the static bypass line.
 6. The inverter shall be capable of at least 300% current for short circuit conditions. If the short circuit is sustained, the inverter shall shutdown and disconnect automatically from the critical load bus.
 7. The inverter voltage regulator is to regulate each phase so that an unbalance loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement.
 8. Power semiconductors in the inverter unit shall be fused with fast acting fuses, so that loss of any one power semiconductor will not cause cascading failures. All fuses shall be provided with a blown fuse indicator with an alarm light on the control panel.
 9. Each inverter shall have fault sensing and static isolation for removal of faulted module from the system without affect on critical load bus beyond specified limits.
 10. All inverter units shall automatically load share at all times for parallel operation. Output inverters of UPS module shall not be more that $5\% \pm$ unbalanced.

D. UPS System Control Cabinet

1. The UPS shall be provided with a separate free-standing system control cabinet. The system control cabinet is to be divided into two sections: 1) control and monitoring section, and 2) a power section.
 - a. System Instrumentation - The system control panel shall be provided with the following metering:
 1. AC voltmeter with selector switch to monitor the UPS output and bypass with the same meter
 2. Output and bypass AC ammeter
 3. Frequency meter with selector switch to monitor the UPS output and bypass with the same meter
 4. Output kilowatt meter
 5. Synchroscope with ON/OFF switchAll meters shall be $4\frac{1}{2}$ " switchboard type with accuracy of at least 1%. A phase selector switch shall be provided for these meters.
 - b. System Alarm Indicators - The system control panel shall contain indicators for the following items. Any one of these conditions shall also turn on the audible alarm.
 1. Module summary alarm, one for each UPS module
 2. Output overvoltage
 3. Output undervoltage
 4. UPS on battery

5. Low battery
 6. Over/Under frequency
 7. Overload
 8. Critical load on bypass
 9. Static switch enable
 10. Provide a low DC voltage alarm at 1.8 volts per cell. The alarm shall provide audible and visual annunciation, as well as drive a NO/NC dry contact to initiate a remote transfer to the Emergency Generator System. The contact shall be located in the system control cabinet and shall be interlocked with a key switch labeled "Initiate transfer to EGS on Low DC Alarm, ENABLE/DISABLE." The remote transfer signal shall be automatically disabled when the UPS is in static bypass.
- c. System Controls - The following system level control functions will be provided:
1. Lamp test/reset.
 2. Audio test/reset.
 3. Voltage adjust $\pm 5\%$.
 4. Emergency Off with protective cover.
 5. UPS/Bypass Transfer switch.
- d. System Mimic Panel - The system control panel shall contain a mimic panel in the format of a single line diagram with status indicators for the following items:
1. Module on-line, one per UPS module.
 2. System output breaker status, one for closed and another for open.
 3. Bypass breaker status, one for closed and another for open.
 4. Static transfer switch status, one for connected and another for disconnected.
- e. Emergency Shutdown - The UPS system control panel shall be provided with local emergency shutdown provisions. Activation of the local emergency shutdown shall cause: 1) the critical load to be automatically transferred to the maintenance bypass uninterrupted and 2) all the module input, output, and battery circuit breakers to open, completely isolating the UPS modules from all sources of power.

E. Power Section

1. The power section of the system control cabinet shall contain a static transfer bypass switch and circuit breakers to collect the output feeder of each UPS module (total of three), input for the bypass line source, and the critical load. The cabinet shall be built to accept bottom entrance feeders as shown on drawings.
 - a. Static Transfer Switch
 1. A static transfer switch with dual bypass circuit breakers or switches shall be provided to transfer the load between the UPS and the bypass line uninterrupted. Automatic static load transfers are to be initiated when a fault within the UPS modules occurs, a system overload is greater than specified herein, or a branch load circuit fails. An interlock shall be provided to release a normally captured kirk key when static bypass is in service.
 2. In the event of a branch load circuit fault, the static transfer switch is to pulse-on for at least 40 milliseconds allowing at least 1000% load current to flow from the bypass line to clear the fault. If the fault is cleared, a load transfer is not to be made. If the fault is not cleared, then the static transfer is to be accomplished maintaining load voltage within specified limits.
 3. The static transfer switch is to be of the energy saving type. Once the load is transferred to the bypass line by the static transfer switch, a circuit breaker is to automatically close, removing the static transfer switch from the power flow, thereby eliminating the energy used by the switch.
 4. A manual load transfer between the UPS and the bypass line is to be initiated from the system control panel. All transfers from the bypass line to the UPS are to be manually initiated allowing the operator to schedule the transfer.
 - b. Test Switch
 1. A fully-rated circuit breaker shall be included in the power section for load bank switchboard connection.

2.05 BATTERY SYSTEM**A. Acceptable Manufacturers**

1. C&D
2. GNB
3. Exide/Yuasa
4. Johnson Control

B. Battery Requirements

1. A battery system shall be furnished for the UPS with sufficient capacity to maintain UPS output at 675 kW for an eight minute duration. The battery is to provide 100% of the specified capacity at initial start-up and 80% at end of life. The battery shall be of the open vented, wet cell type.
2. The battery cells shall be the lead-calcium type. The specific gravity of the electrolyte shall not be less than 1.21 or more than 1.25 at 25 ° C. A float voltage of 2.2 volts per cell is to be used for the lower specific gravity and 2.27 volts per cell for the higher specific gravity.
3. The minimum discharge voltage is not to be lower than 1.67 volts per cell.
4. The batteries shall be manufactured in the same lot. Battery manufacturer shall provide a certificate of conformance and lot indication.
5. Batteries shall have a design life of at 20 years and be so guaranteed by the manufacturer.
6. Batteries shall have flame retardant, thermoplastic covers.
7. Battery jars shall be styrene acrylonitrile (SAN) plastic.

C. Racks

1. All the cells making up the battery shall be installed in a free-standing rack, Seismic Zone, built in three (3) tiers, and protected with electrolyte-resistant paint. Rack system shall meet layout requirements as indicated on the drawings.
2. Each cell is to be held in place to prevent movement during seismic motion.
3. Connectors are to be used so that the battery can be disconnected in no more than 42 volt sections.
4. Intercell and interior connectors for racks, end-to-end and/or back-to-back.
5. Provide clear PVC post covers on all cells to protect against short circuits and accidental shocks.
6. Each rack shall be provided with a modular spill containment barrier with four (4) inch sill and a minimum of a one (1) inch longer than the rack. Battery electrolyte neutralization and absorption pillows shall be included. The spill containment barrier shall be Enviroguard or approved equal.
7. Rack lengths shall not exceed 17 feet.

D. Battery Disconnect System

1. Each UPS module shall have a molded case thermal-magnetic circuit breaker with shunt trip. When open, there shall be no battery voltage present in the UPS module cabinet. The UPS module shall be automatically disconnected from the battery by opening the circuit breaker automatically when the battery reaches the minimum discharge voltage level or when signaled by other control functions.

2.06 CONTROL AND MONITORING PANEL

- A. All of the operator controls and monitors are to be located on the front of the UPS module cabinet. The monitoring functions such as instrumentation, status, and alarms, are to be displayed in numbers and words on a digital display.
- B. Controls

1. Each UPS module shall include the following controls:
 - a. Lamp test/reset push button
 - b. Battery circuit breaker trip push button
 - c. Inverter output circuit breaker trip push button

C. Module Instrumentation

1. The following metering shall be displayed:
 - a. Input AC voltage line-to-line and line-to-neutral for each phase.
 - b. Input AC current for each phase.
 - c. Rectifier output DC current.
 - d. Battery voltage.
 - e. Battery charge/discharge current.
 - f. Output AC voltage line-to-line and line-to-neutral for each phase.
 - g. Output AC current for each phase.
 - h. Percent of rated load being supplied by the UPS.
 - i. Battery time left during battery operation.

D. Alarms

1. The following alarms shall be displayed:
 - a. Input power failed.
 - b. Battery discharging.
 - c. Low battery.
 - d. Overload.
 - e. Overload shutdown.
 - f. Load on bypass.
 - g. Equipment overtemperature.
 - h. Overtemperature shutdown.
 - i. Fan failure.
 - j. DC overvoltage.
 - k. Control power failed.
 - l. Output overvoltage.
 - m. Output undervoltage.
 - n. Fuse open.
 - o. Rectifier/charger failure.
 - p. Static transfer switch failure.

E. Remote Alarm Panel

1. A wall-mounted NEMA 1 enclosed remote alarm panel is to be provided and is to include the following:
 - a. UPS on battery alarm for each module
 - b. Low battery alarm
 - c. Load on bypass alarm
 - d. Summary alarm for all module malfunctions
 - e. New alarm - a separate alarm for a second summary alarm condition
 - f. Audible alarm with reset push button
 - g. Lamp test/reset push button

All alarm lights shall be long life LED type; incandescent bulbs shall not be used. An audible alarm is to come on when any of the above alarms come on.

2.07 PROTECTION

- A. Protection Against External Events: The UPS system shall have built-in protection to prevent permanent damage against the following:
 - 1. Overvoltage, undervoltage, and overcurrent surges introduced by the primary AC source.
 - 2. Overvoltage and overcurrent surges introduced on the output terminals by sources in the load, load switching and fault clearings in the distribution system of the load.
- B. Protection Against Internal Events: The UPS system (including the battery) shall have built-in protection against permanent damage to itself and the connected load for all predictable types of failures within the UPS. Protective devices shall be provided for power semi-conductors, these devices shall be configured in such a way as to prevent cascading failures. The operation of any protective device shall be so indicated by the diagnostic system.
- C. Emergency Shutdown: The UPS shall be provided with the means of turning off the UPS and disconnecting power to the load both locally and remotely.
 - 1. Local: By a single operator switch
 - 2. Remote: By the opening of an external customer supplied contact
- D. Grounding: The UPS module output AC neutral shall be electrically isolated from the UPS module chassis. The UPS module chassis is to be provided with an equipment ground system terminal block capable of accepting a full parity equipment grounding conductor.

2.08 EQUIPMENT DETAILS

- A. All materials and parts comprising the UPS shall be in excellent operating condition or refurbished by a manufacturer's representative to be free from all defects and imperfections.
- B. All active electronic devices shall be solid state. All semiconductor devices shall be hermetically sealed. All relays shall be dust-tight.
- C. The maximum working voltage, current, and di/dt of all solid state power components and electronic devices, shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid state component cases shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 90% of their voltage rating.

PART III - EXECUTION**3.01 INSTALLATION**

- A. Installation of the UPS system shall be in full accordance with and under the site technical supervision of the manufacturer. A manufacturer's representative shall inspect the equipment upon arrival and issue a written report on same.
- B. All equipment specified herein shall be installed and interconnected by the electrical contractor under a separate contract.
- C. All troubleshooting at site shall be performed by UPS manufacturer's own personnel.
- D. Sectional, removable, plastic covers (to be returned to the manufacturer) shall be provided during shipment and installation of the UPS system to protect the UPS system from dust, rain or dirt at all times, except while working on a given item of equipment after which the plastic covers will be reinstalled.

3.02 WIRING

- A. Access holes with cover plates are to be provided on the top and bottom of the UPS and battery cabinets for intercabinet wiring and customer installation wiring.
- B. Wiring practices, materials, and coding shall be in accordance with the requirements of the National Electric Code, OSHA, and applicable local codes and standards.
- C. All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electric Code and other applicable standards. All electrical power connections are to be torqued to the require value and marked.
- D. All connections hardware to be provided with the UPS.
- E. All input and output feeders shall be copper installed in EMT conduits. All control wiring shall be installed in EMT conduits.

3.03 CONSTRUCTION AND MOUNTING

- A. UPS shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling.
- B. Wire runs shall be protected in a manner which separates power and control wiring. Provisions shall be made in the cabinets to permit installation of input, output, and inter-cabinet cabling, using conduit.
- C. The UPS cabinets shall be cleaned, primed, and painted with the manufacturer's standard color.

3.04 VENTILATION

- A. Adequate ventilation shall be provided to insure that all components are operated within their environmental ratings. All fans are to be equipped with wind vane sensors connected to an alarm on the module control panel. Ventilating fan shall be redundant.
- B. Temperature sensors shall be provided to monitor temperature of critical components. Upon detection of temperatures in excess of component manufacturer's recommended ambient working temperature, the sensors shall cause audible and visual alarms to be sounded on the module control panel.

3.05 SITE INSPECTION

- A. Examine the areas and conditions under which the UPS equipment will be installed and notify in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in an approved manner.

3.06 IN-PLANT TEST

- A. The Uninterruptible Power Supply (UPS) System shall be inspected and tested in the manufacturer's plant to demonstrate full compliance with the requirements of these specifications for modules as well as the entire system.
- B. All routine factory tests shall be completed prior to beginning of witnessed tests. The Owner's Representative will be notified 2 weeks prior to witness testing. Witnessed tests shall be in addition to those deemed necessary by the manufacturer and at a minimum shall consist of the following:
 - 1. Alarm and Functional Tests
 - a. Verify the function and operation of all meters, controls, operator adjustments, lights, alarms, breakers, key interlocking and trip condition. Module and system level.

- b. An individual test to verify the specified operation of all contacts and signals being supplied to the building management system.
- 2. Dielectric Test
Each module and the switchgear will withstand 1500 volts rms, at 60 Hz frequency, successively applied for one minute between each electric circuit and all other electric circuits with metal parts grounded. Solid state devices may be removed with the circuits during this test. The equipment will not be damaged during tests and will function satisfactorily when installed in the system after completion of the dielectric tests.
- 3. Transient Tests
 - a. The system will be subjected to transient tests. A high-speed oscillograph will be used to simultaneously record phase current and voltages. The speed of the oscillograph should be sufficient to identify each 1/2 cycle. A Dranetz 626 recording instrument will be continuously connected to the system for all heat runs and transient testing.
 - b. 25% Increment Load Transient Test to 100% Full Rate Load.
- 4. Static Switch Test
 - a. Static switch will be instrumented with thermocouples mounted at the hot-spot of each type power component, SCR's circuit breakers, and exhaust air from the switch.
 - b. One phase of the static switch will be shorted during full load operation and results recorded.
 - c. System input power to the total UPS, including the by-pass line, will be removed and results noted.
 - d. Restore power to all inputs simultaneously and record results.
 - e. Cease test at UPS immolation or after ten (10) times.
 - f. Provide full documentation of failure modes (if any).
 - g. Burn-In Test: An 8 hour, full load, burn-in test shall be performed with recording meter.
- 5. Test Reports
 - a. Witness Test Reports are required for all testing listed above.
 - b. Five copies will be given to Owner's Representative at conclusion of factory testing for final review.
 - c. Equipment will not be shipped until final review is complete by Owner Representative.

3.07 INSPECTION

- A. Inspection and approval before shipment is required. Manufacturer shall notify the Owner's Representative at least two weeks before his shipping date so that arrangements can be made.

3.08 ON SITE SUPERVISION AND TESTING

- A. General Requirements: Test procedures will conform to standards of the American Society of Mechanical Engineers, the Institute of Electrical and Electronic Engineers, the American National Standards Institute, and the National Electrical Manufacturers Association standard practices for testing of motor-generator sets, rectifiers, inverters, and switchgear.
- B. After installation by others, the equipment manufacturer shall provide the services of a competent engineer to instruct the electrical contractor and to coordinate the wiring between all pieces of equipment.
- C. The manufacturer shall provide the services of a competent engineer to start up the system and field-test all functions, interlocks and protection devices, to ensure that the total system is functioning according to the intent of the design prior to executing Owner's test.
- D. The system shall undergo a complete battery discharge test to full depletion with voltage being sampled every five seconds and a recharge to nominal conditions.
- E. In the event any of the equipment fails to meet the specified requirements, or fails to operate satisfactorily, the Owner's Representative will have the right to operate the equipment until the defects have been corrected. The Owner's Representative will reject any equipment proved to be faulty or

inadequate for the service specified, but will have the right to operate the rejected equipment until such time as new equipment is provided by the Manufacturer to replace or repair the equipment rejected.

- F. Each UPS will be operated by the Manufacturer for a period of time sufficient to assure that the equipment is ready to carry the test loads specified herein without damage to any parts. During this preliminary operation, the Vendor will check the operation of all equipment furnished to determine that it is functioning properly, and he will make such adjustments to all equipment as are necessary to place it in first class operating condition in conformance with the requirements.
- G. In the presence of the Owner's Representative, the manufacturer will conduct tests on the UPSs and all accessories to determine compliance with the specified requirements and such other test as the Owner's Representative deems necessary or desirable to make certain that all equipment is functioning properly.
- H. These tests will include, but are not limited to, the following:
 - 1. An individual test to verify the specified operation of all alarms, metering and trip condition, module and system level.
 - 2. Ten (10) uninterrupted transfers to and from the by-pass.
 - 3. Ten (10) successful transfers from and to inverter operation.
 - 4. A 480 Volt, 675 kW load bank shall be used for the UPS equipment testing. Cabling and load banks will be furnished by UPS Supplier and connected by the installation contractor.
 - 5. Twelve hour system burn-in on site.
Note: Should any system fail the twelve hour test for any reason, that system will be repaired, a report made as to reason of failure, and the entire test will be repeated. This test will be performed with module configurations similar to that required for factory test.
 - 6. 25% increment load transient tests to 100%. (Visicorder or other instrumentation supplied by Manufacturer.)
- I. An individual test to verify the specified contacts and signals for connection to the Building Management System.
- J. Prior to energizing the battery the following shall be performed:
 - 1. Check electrolyte temperature
 - 2. Specific gravity of all cells
 - 3. Individual cell voltage readings
 - 4. Check connection resistance at all posts with a microohmmeter
 - 5. UPS manufacturer will have battery supplier inspect the battery.
 - 6. DC disconnect contact resistance.
- K. After discharge test, microohmmeter tests will be repeated.

3.09 WARRANTY

A. UPS Equipment

The manufacturer shall provide a full two year parts, labor and maintenance warranty on the UPS system. The manufacturer shall warrant the satisfactory and successful operation of all components, material and structure furnished under these specifications at the rating, under the conditions and for the service specified. The manufacturer further warrants the equipment to be as represented and specified and shall warrant against any and all defects in design, material and workmanship, and shall, upon written notice by the purchaser, remedy such defects as develop under the specified and ordinary use of this apparatus, within two years of actual service, such service to begin after final acceptance by the Builder.

B. Battery

The UPS batteries shall have a (3) three year unconditional replacement of parts, labor and maintenance warranty. At the end of three years, the batteries shall be covered by a (17) seventeen year parts warranty on a prorated basis.

3.10 MAINTENANCE

A. The manufacturer shall include in his bid price the cost for a three year maintenance contract of the UPS starting from the date of acceptance of the equipment by the Owner. This maintenance agreement shall include, as a minimum, the following provisions:

1. Preventive Maintenance: During the contract period the manufacturer's maintenance staff shall visit each installation a minimum of four (4) times (one per quarter) for routine inspection and preventive maintenance. All schedules of preventive maintenance work shall be approved by the Owner prior to such work.
2. Remedial (emergency) maintenance: Remedial work shall have a guaranteed maximum response time after request of less than four hours.
3. Design improvements: Any engineering design improvement modifications developed during the contract period, whether safety or operation and performance related, shall be installed during scheduled preventive maintenance visits at no extra cost to the Owner.
4. Parts replacement: The manufacturer shall promptly replace at no charge any and all parts used during the contract period (whether or not included in the spare parts list). Parts, labor, site time, site transportation, site expenses, and freight to and from the site of any parts shall all be provided at no charge to the Owner. Any spares used shall be replenished by the manufacturer immediately after use at no charge to the Owner.
5. Battery inspection: The maintenance contract shall include periodic inspections of the battery during discharge or microvolt drop reading (digital) across each connection under float conditions for detection and correction of any loose connections.
6. Off-hours work: Any overtime or weekend work for remedial (emergency) maintenance tasks shall be at no extra costs to the Owner.
7. Unlimited Remedial Visits: The maintenance contract shall include as many remedial or emergency visits as are found necessary during the contract period. No limitations to the number of visits or charges for additional visits are permitted.

3.11 TRAINING

A. The manufacturer shall provide one day of on-site training for a maximum of five Owner personnel in the operation of the system. Training will be done after acceptance of the work by the owner. The time and date for this training period shall be coordinated with the Owner. Manufacturer shall provide applicable manuals for each trainee one day prior to training and a videotape of training session.

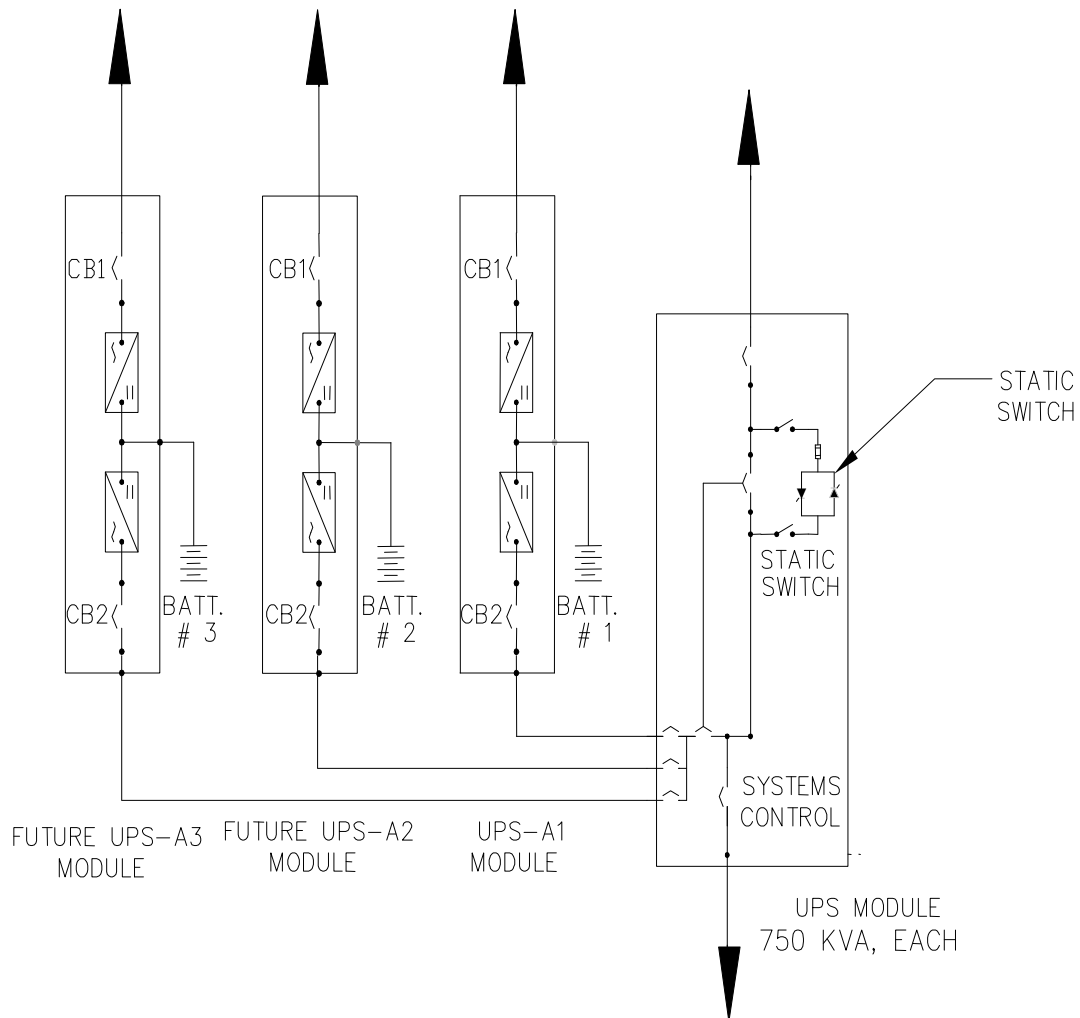
3.12 SPARE PARTS

- A. Provide as part of the base bid, six spare part fuses for each type of installed fuse, five spare air filters of each type used, and twelve lamps (or LEDs as applicable) of each type used.
- B. The manufacturer shall propose a recommended spare parts quotation on or about the date of acceptance of the equipment at site (to be purchased under separate contract) for selection and purchase by the Owner. The list shall, as a minimum, include all parts required to be on site to support the manufacturer's maintenance contract program.

3.13. ACCEPTANCE

A. The operation of the installed equipment does not constitute an acceptance of the work by the owner. The final acceptance is to be made after the equipment has been adjusted and has demonstrated that it

fulfills the requirements of these specifications and supplier has furnished all required documents in accordance with the specified testing procedures.



SKETCH "SC"
UPS System Control Cabinet

END OF SECTION 16611

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 SYSTEM CONSIDERATIONS**

- A. These specifications describe requirements for a complete power distribution system using ten (10) 300 kVA Power Distribution Units (PDU), supplying computer-grade power to sensitive loads. The specified system shall provide isolation, distribution, control and monitoring of AC power. It shall include all equipment to properly interface the AC power source to the intended load.
- B. The PDU shall provide four (4) 225 amp 42 pole panel and two (2) 225 amp subfeed circuit breakers and an input short circuit current rating of 42,000 RMS symmetrical amperes.
- C. The PDU shall be capable of communications via a site link module or equivalent Modbus protocol.
- D. The PDU shall be front accessible.
- E. 30" Floor Stands: Provide floor stand to isolate system from access floor. Floor stands shall be constructed of permanently welded members.
- F. Provide ten (10) J-box for future PDUs.

1.02 APPLICABLE STANDARDS

- A. The specified system shall be designed, manufactured, tested, and installed in compliance with applicable UL, CSA, NEC, NFPA, ANSI, IEEE, NEMA, FIPS Publication 94, and local codes having jurisdiction.
- B. The system shall be UL listed as a complete system under UL 478 "Standard for Electronic Data Processing Units and Systems". (Now superseded by UL1950, standard for Safety for Information Technology Equipment.)

1.03 FACTORY TESTING

- A. The specified unit shall be completely factory-tested before shipment. Testing shall include, but shall not be restricted to the following: Quality Control checks, "Hi-Pot" test, and Metering Calibration tests.

1.04 SUBMITTALS

- A. A list of recommended spare parts including prices shall be supplied.
- B. An in-service user's list shall be furnished upon request.
- C. Submit three copies of installation manual with installation, startup, and maintenance instructions for specified system. In addition, wiring diagrams and drawings of major components shall be furnished for customer reference.

1.05 SERVICE

- A. Factory and site startup 24x7, for the specified unit shall be available and included in the bid price.
- B. Preventive maintenance and full service for the specified unit shall be available upon request on a 24 hour, 7 day per week cycle.

1.06 WARRANTY

- A. The manufacturer shall provide a one-year warranty against defects in material and workmanship. A five-year extended warranty on power components shall be provided, if requested.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Acceptable manufacturers are as follows:

1. Liebert
2. MGE
3. PDI
4. United Power
5. Powerware

2.02 GENERAL SYSTEM REQUIREMENTS

- A. Electrical Requirements

1. Output capacity shall be via 300 kVA PDU.
2. Input voltage shall be 480 volts AC at 60 Hz three phase, three wire plus ground.
3. Output voltage shall be 120/208 volts AC three phase, four wire plus ground, wye configuration.

- B. Environmental Requirements

1. Storage temperature range shall be -55° to 85° C.
2. Operating temperature range shall be 0° to 40° C.
3. Operation shall be reliable in an environment with 0% to 95% non- condensing relative humidity.

- C. The audible noise level of the specified system shall be less than the ANSI C89 standard for transformers.

- D. The specified system shall comply with latest FCC EMI emission limits under Class A computing devices.

2.03 SYSTEM COMPONENTS

- A. Input Connections

1. High Voltage Connections:

- a. A high voltage junction box shall be provided for input power connections. Power terminal blocks shall be provided for connection of the input power conductors, and a parity-sized insulated ground conductor. The junction box shall have maximum dimensions of 16" wide, 30" long, and 6" high.
- b. A high voltage main input cable shall be provided for connection between the specified unit and junction box. The cable shall be 10 feet long, and consist of the appropriate number and size of conductors inside a UL/CSA listed liquid tight, flexible metal conduit.
- c. The conductors shall be UL/CSA listed, 90° C maximum insulation, copper conductors, sized in accordance with the NEC, based on the main input circuit breaker rating. Both for reliability and per the NEC, no plug-and-receptacle connectors shall be used for the high voltage input power cable(s).

2. Low Voltage Connections

- a. A separate low voltage junction box shall be provided for connecting all building interface alarms and controls, and all Remote Emergency Power Off (REPO) switches. The low voltage junction box shall also contain a 24 VDC, DPDT building interface relay for interfacing with environmental systems, alarm panels, etc. The relay contacts shall be rated for use up to 10 amps at 240 VAC. The low voltage junction box shall have maximum dimensions of 8" wide, 10" long, and 4" high.
- b. A low voltage control cable shall be provided for connection between the unit and the J-box. The low voltage control cable shall utilize UL/CSA listed liquid tight, flexible metal conduit, measuring 10 feet long.

B. Frame Construction and Enclosure

1. The frame shall be constructed of welded steel to provide a strong substructure. The enclosure shall be mounted on four heavy-duty swivel casters for portability and ease of installation, and shall be provided with permanent leveling jacks for final installation. The unit shall have easily removable and interchangeable output cable trays for each panelboard to allow matching of the size and number of cable/conduit openings to the site requirements. Retrofitting additional power distribution cables shall require access to the front of the unit only. A tool shall be required to remove the exterior panels that access the high voltage area of the unit. To ensure grounding integrity and for static protection and EMI/RFI shielding, the removable exterior panels shall be grounded to the frames by way of stranded copper wire. Hinged double front panels shall provide access to the main input circuit breaker, and to all output circuit breakers.
2. The unit shall be naturally convection cooled. No fans for forced air-cooling system shall be used. The convection cooling method shall allow continuous full load operation without activation of overtemperature circuits. Heat rejection shall be through a screened protective top that prohibits entry of foreign material.
3. The frame shall be configured to accept future field installation of additional bolt-on distribution sections containing additional panelboard and cable tray capacity.
4. The complete system shall be a maximum of 32" wide by 32" deep. The distributed floor weight shall be less than 250 lbs. per square foot.

C. Main Input Circuit Breaker: The specified unit shall be equipped with a main input circuit breaker to provide overcurrent protection and a means for disconnecting power to the unit. The main input circuit breaker shall be a three pole thermal magnetic molded case circuit breaker sized for 125% of the specified full load input current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be 42,000 RMS symmetrical amperes at 480 volts AC. The main input circuit breaker shall include a 24 VDC shunt trip mechanism to interface with REPO buttons and other remote controls as required by the NEC and local codes.

D. Manual Restart: The specified unit shall be equipped with a manual restart feature to allow for an orderly supervised startup after power failure. The control circuit shall automatically energize the shunt trip mechanism of the main input breaker upon sensing output voltage failure. A field selectable auto restart mode shall be provided to deactivate the manual restart if desired.

E. Transformer

1. The unit shall contain an electrostatically shielded isolation transformer with a rating as described in Paragraph 2.02. The transformer shall be a dry type, three phase, common core, and convection air-cooled transformer. The transformer shall conform to ML-T- 27B, with Class H, 220° C minimum insulation. All transformer windings shall be copper. The transformer shall exhibit the following characteristics: percent impedance 3.0 - 5.5%; common mode noise attenuation 120 dB; harmonic distortion 0.5%; full load efficiency 96.5 - 98%.
2. The transformer shall be a non-linear type with a K-13 rating.

3. The isolation transformer shall be provided with six full capacity compensation taps at 2½% increments to accommodate field adjustment to match the source voltage. These compensation taps shall be easily accessible by removal of one exterior panel. Tap changes include two, 2½%, full capacity, above nominal and four, 2½%, full capacity, below nominal.
 4. The unit shall be provided with additional thermal overload protection for the transformer. An alarm shall notify personnel if the transformer temperature reaches 180° C. The unit shall automatically shut down if the transformer temperature reaches 200° C.
- F. Computer Grade Ground: The specified system shall include a computer grade, single point ground in accordance with computer manufacturer's recommendations, FIPS Publication 94, and the requirements of the NEC. The transformer output neutral shall be solidly grounded in accordance with NEC article 250-30.
- G. Secondary Class Surge Arrester: The specified unit shall be equipped with a secondary class surge arrester to divert high voltage power surges quickly and safely to the ground. The surge arrester shall be mounted ahead of all electrical components to provide maximum protection of the unit insulation and wiring. The surge arrester shall be capable of repeated operations. It shall consist of a nonlinear resistance element to offer low resistance to the flow of surge current. The surge arrester shall be rated for a maximum FOW spark over of 3200 volts with maximum discharge voltage of 2.2 kV at 1500 amperes, assuming a standard 8 x 20 microsecond waveform.
- H. Spike Suppression Module
1. The unit shall be equipped with a spike suppression module to eliminate high speed, high-energy transients and to filter high frequency noise. The suppressor module shall be mounted on the output of the unit. The spike suppressor components shall be UL recognized.
 2. The suppressor shall utilize high-energy metal oxide varistors with less than 1 nanosecond response time. The clipping level shall be 184 volts on a system with a nominal peak line voltage of 170 volts, and 354 volts on a system with a nominal peak voltage of 340 volts. Peak current handling capability shall be at least 15,000 amperes. Energy absorption capability shall be at least 200 joules.
 3. A passive filter, utilizing metalized polypropylene film capacitors, shall provide normal mode noise attenuation of at least 18 dB at 10.5 kHz. The capacitors shall be equipped with an integral pressure sensitive interrupter to provide short circuit current interrupting capability of up to 10,000 amperes at 600 VAC.
- I. Remote Emergency Power Off (REPO) Switches: Provisions shall be available for adding multiple REPO switches to meet specific site needs and local codes. The REPO switch shall activate the shunt trip of the main input circuit breaker to shut down the system. Each REPO shall be a fully guarded, normally open, illuminated switch in a wall box
- J. Floor stands: Provide 30" floor stand to isolate system from access floor.

2.04 LOCAL VOLT/CURRENT MONITOR PANEL (VCMP)

- A. The system shall have a local volt/current monitoring panel (VCMP) along with an identifying system number. The VCMP shall include the following:
1. Monitored Parameters: The VCMP shall be able to select and monitor output voltage line-to-line and line-to-neutral for each phase, each output phase current, output neutral current, ground current, and output kVA. A power flow diagram, with indicators, shall be provided for visual indication of each input and output phase.
 2. Function Selection: The VCMP shall have the capability of manual parameter selection by way of the FUNCTION key. The VCMP shall also include an "Autoscan" mode, which provides continuous sequential selection and display of all parameters. A three digit LED display, integral to the VCMP, shall indicate the value of the selected function.

3. Alarm Annunciation: The VCMP shall detect and annunciate by audible alarm and LED indicators the following abnormal conditions:
 - a. Output overvoltage
 - b. Output undervoltage
 - c. Transformer overtemperature
 - d. Alarm present/silence: During an alarm, the switch shall be lit (in conjunction with indicating LED and audible annunciator). Pressing the switch shall silence the audible alarm.
4. Remote Emergency Power Off (REPO): The local REPO circuit shall include a fully guarded and illuminated pushbutton labeled "REMOTE EMERGENCY POWER OFF". Pressing the REPO shall immediately power down the system by activating the shunt trip on the main input circuit breaker. As a part of the REPO circuit, an interface shall also be provided for connecting REPO switches.
5. External System Communication: The VCMP shall be able to communicate with the centralized monitor/control system all monitored parameters and alarms. This data shall be sent via a two wire, twisted pair, low voltage signal communication circuit, using RS-422 format for reliable communication to 1,000 feet.
6. The VCMP shall also monitor individually all distribution-sub feed breakers.

END OF SECTION 16612

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 SYSTEM CONSIDERATIONS**

- A. These specifications describe requirements for a complete Remote Distribution Center (RDC) supplying computer-grade power to sensitive loads. The RDC is designed primarily for distribution of electrical power in a computer room, and shall be housed in a full depth enclosure that resembles standard data cabinets. Design shall also permit its use in office, factory, and other applications. Furnish six (6) RDC units constructed as specified herein.
- B. Each RDC shall have (4) 42 pole panels.
- C. Each RDC panels shall be dual fed, with a barrier separating the front and rear of the full depth RDC enclosure.
- D. Floor Stands: Provide (30") floor stand to completely isolate system from access floor. Floor stands shall be constructed of permanently welded members.

1.02 APPLICABLE STANDARDS

- A. The specified system shall be designed, manufactured, tested, and installed in compliance with applicable UL, CSA, NEC, NFPA, ANSI, IEEE, NEMA, FIPS Publication 94, and local codes having jurisdiction.
- B. The system components shall be UL listed

1.03 FACTORY TESTING

- A. The specified unit shall be completely factory-tested before shipment.

1.04 SUBMITTALS

- A. A list of recommended spare parts shall be supplied at the Owner's request.
- B. Submit three (3) copies of installation manual with installation, startup, and maintenance instructions for specified system. In addition, wiring diagrams and drawings of major components shall be furnished for customer reference.

1.05 WARRANTY

- A. The manufacturer shall provide a one year warranty against defects in material and workmanship. A five year extended warranty on power components shall be provided, if requested.

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Acceptable manufacturers are as follows:
 - 1. Liebert
 - 2. PDI
 - 3. United Power
 - 4. APC

5. Powerware

2.02 GENERAL SYSTEM REQUIREMENTS

A. Normal Operation

1. The RDC provides distribution, control and monitoring of AC power. The RDC distributes power to connected load devices. Branch AC distribution panels apply power to specific loads. Load circuits can be controlled manually from distribution panelboards.

B. Electrical Requirements

1. Up to 225 amp per panelboard with four 42 pole panelboards as indicated on the drawings.
2. Input voltage shall be 208/120 volts AC at 60 Hz three phase, 3 phase, 4 wire plus ground.
3. Output voltage shall be same as input voltage.

C. Environmental Requirements

1. Storage temperature range shall be -40° to 40° C.
2. Operating temperature range shall be -10° to 60° C.
3. Operation shall be reliable in an environment with 10% to 90% non- condensing relative humidity.

2.03 SYSTEM COMPONENTS

A. Panelboards: The RDC is provided with two (2) output distribution panelboards, each with the following characteristics and/or features:

1. Each 42 pole breaker panel shall be protected by a main breaker rated at 22 KAIC.
2. Branch circuit breakers shall be universal, plug-in and bolt-on.
3. Pole Capacity: 42 poles, capable of accepting 1, 2, or 3-pole circuit breakers
4. Buss Rating: 225 Amperes, 22 KAIC
5. Copper Ground bus: 42 terminals
6. One panel shall be located on each side (back and front) with a barrier in the center isolating the front and rear of the enclosure.
7. Copper Neutral Bus: Rated for 200% of nominal phase current

B. Panelboard Schedules: Schedules will be completed by the Electrical Contractor during construction with descriptions of each circuit in accordance with Article 110-22 of the National Electric Code as provided by the owner in a software spreadsheet or database format.

C. Computer AC Power Cables

1. All computer AC power cables will be purchased, installed and connected by others at the time of the installation of the RDC units in field. The RDC assembly and panelboards shall be suitable for the connection of the computer cables specified below.
2. All cables will consist of flexible metal conduit containing the required insulated power, neutral and ground conductors as established by the National Electric Code. The power cable will include an insulated, liquid tight, flexible and interlocking wound steel armored outer shield, which surrounds all of the conductors to minimize electrical and or mechanical disturbances to the conductors. The flexible conduit will contain a continuous copper ground conductor built into the core. Material used for the outer shield will conform to and be listed to UL Standard for Safety No. 360 (Conduit, Electrical, Liquid-Tight Flexible Steel).
3. All cables will contain a minimum of 72 inches (6 feet) of free conductors for attachment to power source.

4. The output conductors, liquid tight flexible metal conduit and fittings will be sized in accordance with the National Electric Code and are listed by Underwriters Laboratories and bear the appropriate UL mark.

D. Branch Circuit Breakers

1. All branch circuit breakers will be purchased and installed by others at the time of the installation of the RDC units in field. The breakers will be provided based on the panel circuit schedules on the construction drawings. Each load will be protected by an individual branch circuit breaker as shown on the panel schedules. The panelboards shall be constructed to accept the branch circuit breakers described herein. The branch circuit breaker shall provide overcurrent protection and "ON - OFF" switching to the specified load. Single pole, two pole, and three pole bolt-on and plug-in type branch circuit breakers up through 100 amperes will be utilized. Each circuit breaker shall clearly identify the "ON", the "OFF", and the "TRIPPED" positions. All branch circuit breakers shall have a minimum interrupting capacity of 22,000 RMS symmetrical amperes at 120/208 VAC. Each branch circuit breaker will be sized in accordance with the NEC and shall be UL/CSA listed. Branch circuit breakers shall have an associated directory label, located adjacent to the breaker, identifying the branch circuit number and the equipment being served.

E. Frame Construction and Enclosure

1. The RDC is housed in a free-standing, full rack depth (38") computer data type enclosure with dead front construction and lockable front and rear doors. The cabinet shall be made with an extruded aluminum welded frame. The side panels shall be 18 gage steel. The solid steel doors and top panel shall be 16 gage steel. The RDC shall have a 12 gage steel bottom conduit landing panel capable of accepting a conduit for each pole in the panelboards and two 2-1/2" input feed conduits sized for each panelboard. The system input and output circuit breakers and all customer power and control connection points shall be accessible from the side of the enclosure. All circuit breakers shall be protected with hinged dead front panels having lift off hinges and 1/4 turn captured fasteners. Doors and outside panel color shall be black or pearl white, textured, dry powder coat finish, designed to resist scratching. The cabinet is mounted on heavy-duty casters with leveling jacks. The overall size of the RDC is 78" high, 24"W and 39" deep up to 168 poles. The RDC requires 36" inches front, rear and one side clearance to make connections.
2. One panel shall be located on each side (back and front) with a barrier in the center isolating the front and rear of the enclosure.
3. The RDC shall be naturally convection cooled. No fans for forced air cooling system shall be used. The convection cooling method shall allow continuous full load operation without activation of overtemperature circuits. Heat rejection shall be through a screened protective top, which prohibits entry of foreign material.

- F. Computer Grade Ground: The specified system shall include a computer grade, single point ground in accordance with computer manufacturer's recommendations, FIPS Publication 94, and the requirements of the NEC.

END OF SECTION 16615

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 SCOPE OF WORK**

- A. The dealer shall furnish two (2) 2000 kW standby power units, including all equipment, materials, and labor to insure complete, functional, and reliable standby power. Only manufacturer's authorized dealers who have a minimum of twenty-five years experience in the field of power generation with the same manufacturer whose products are being offered and can certify to this requirement, are allowed to supply equipment for this project. The dealer must be authorized by the manufacturer to administrate warranty for the engine generator set and must employ factory-trained mechanics.
- B. Related Sections:
 - 1. Section 16428: Generator Paralleling & Closed Transition Low Voltage Switchgear

1.02 MATERIALS AND WORKSHOP

- A. The engine generator set shall be a factory fabricated and assembled package of new and quality grade components. Only those products currently being manufactured for the purpose of power generation will be considered. All work shall be of the highest quality performed by experienced personnel in the field of power generation.

1.03 DESIGN

- A. The unit shall be designed and fabricated to meet all applicable codes and standards associated to the area and application for which it is intended. The complete installation shall conform to UBC 16000, Earthquake Loads, and all equipment must meet seismic design appropriate for an importance factor of III (essential facility) and a ground motion acceleration as indicated in the International Building Code Sections 1614 and 1615. Routine maintenance and adjustments shall be performed without the use of special tools or instruments.
- B. Engine Exhaust Emissions: Comply with applicable Federal, State, and Local Government requirements. Provide dynamic engine, generator, fuel and power control system specifically designed to minimize visible and non-visible products of combustion during start-up and running.

1.04 MANUFACTURER

- A. All major components shall be manufactured and assembled by a manufacturer currently engaged in the production of like equipment. Proof that similar units have been supplied, installed, and satisfactorily placed in service is required at time of bid. The authorized dealer of the manufacturer shall submit with his bid proof that they or other qualified factory representatives in the area have 24 hour pager service coverage 7 days per week with parts and service facility within a 50 mile radius of the job site. The equipment manufacturer shall be approved as specified. Approval to bid shall not be construed as approval to deviate from the specifications.

1.05 WARRANTY

- A. Equipment furnished under this section shall be guaranteed by the manufacturer and administered by the selling dealer against defects in materials or workmanship for a period of one (1) year from date of initial use. It shall cover full parts and labor.
- B. The manufacturer's authorized service agent shall provide person-to-person voice communication within one hour of owner's request for service. Manufacturer's agent shall have means of recording all requests for service made via telephone. This shall include electronic time tag. Manufacturer's agent

shall further respond to the Owner's site within two hours of the initial call, fully prepared to rectify the situation.

1.06 SUBMITTALS AND DRAWING REQUIREMENTS

- A. Compliance: At the time of bid, supplier must submit a certificate indicating compliance with the specifications. A copy of the manufacturer's printed and published service manual, parts book, installation guide, operation guide, service directory, and warranty shall be available to the Engineer during bid evaluation.
- B. Submittal Data: The successful bidder shall submit, within one (1) week of issuance of purchase order, six sets of bound submittals including, but not limited to the following:
 - 1. Standard manufacturer's printed specification sheet showing critical engine and generator set specifications including dimensions, weights, and guaranteed fuel consumption at 25%, 50%, 75%, and 100% of full rated load, engine bhp available, jacket water heat rejection, cooling pump characteristics, exhaust flow rate and temperature at rated load, ventilation requirements, combustion air requirements, maximum allowable air flow and ambient temperature restrictions, exhaust back pressure limitation, rolling ampere rate for electric starting, liquid refill capacities, generator efficiency at 50%, 75%, and 100% load, generator set ventilation requirements, TIF, harmonic wave distortion, direct axis transient reactance (x''d), direct axis sub transient reactance (x''d) type of winding insulation, generator temperature rise, regulation characteristics, generator type of construction and overspeed capabilities, and short circuit current capability curves.
 - 2. Engine and generator material composition and construction.
 - 3. Standard manufacturer's printed warranty statement of the engine and generator set showing single source of responsibility by the engine manufacturer.
 - 4. Generator control panel equipment and features.
 - 5. Accessory catalog cuts including the flexible exhaust coupling, muffler, batteries, mainline circuit breaker and enclosure, engine manufacturer's shutdown, contactors, fuel lines, jacket water heater, and voltage regulator. Include a detailed statement concerning non-engine generator set manufacturer's responsibility and duration of policy.
 - 6. Standard dealer preventative maintenance contract for review and adoption under a separate contract. Dealer must have existing contracts and personnel and contractual detailed performance information available.
 - 7. Normal operating range for systems temperature, pressure, and speed.
 - 8. Spare parts list.
 - 9. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.
 - 10. Phone numbers of 24-hour products support contacts or locations.
 - 11. Drawing and wiring schematics of proposed assembly; battery rack, muffler, and flexible fittings.
 - 12. Provide complete octave band, sound pressure levels in dB for the 'A' scale and in each of eight octave bands at distances three feet, twenty-five feet, and fifty feet from the engine with 0%, 50%, and 100% load.

PART II - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Caterpillar
- B. Cummins/ONAN
- C. Spectrum - Detroit Diesel
- D. Kohler

The standby generator set as specified is based on an acceptable unit. The Vendor shall be responsible for any engineering changes and costs that may be incurred with substitution. Only engine manufacturer's standard rating shall be acceptable, no dealer special ratings will be approved.

2.02 GENERATOR SET CHARACTERISTICS

A. Rating at 1800 RPM: 480/277 volt

1. Standby kW with fan: 2000 kW
2. Power factor: 0.8
3. Frequency: 60 Hz

B. The specified standby kW shall be for continuous electrical service, interruption of the normal utility source, per NEMA standards.

2.03 COMPONENTS

A. Engine: The engine shall be water-cooled, compression-ignited, rated for continuous standby application. It shall produce sufficient horsepower to achieve ratings as shown on the drawing while driving all accessories and parasitic loads such as fuel, lube oil, and jacket water pumps. The engine cylinders shall be equipped with replaceable cylinder liners and shall be fully water-cooled. Pistons shall be one piece, three ring design with cast in iron banks for the top two minimal restrictions and long life. Connecting rods shall be forged, hardened, and peened for increased strength. Main and rod bearings shall be of aluminum construction with copper bonding to the lead tin overlay, super finished for uniform film. A fuel priming pump shall be standard equipment. The engine shall incorporate one piece high strength cylinder heads. The cylinder block shall be of single piece construction and constructed in such a way that liner shall rest on top of the block with a spacer plate installed between the block and cylinder head. Each cylinder shall have a continuously pressurized oil cooling jet directed at bottom of the pistons.

B. Governor: The engine shall be equipped with a speed control with 0 (isochronous) speed drop from no load to full rated load and steady state speed regulation shall be $\pm 0.25\%$ over a range of -40° to 75° C. The governor shall be Woodward electronic type with speed control.

C. Safety Device: The generator set shall have installed and be warranted by the engine manufacturer the following alarms and shutdowns.

1. Oil pressure shutdown with step protection at high and low idle
2. High water temperature shutdown
3. Overspeed shutdown
4. Overcrank shutdown
5. Emergency stop push-button

D. Cooling System:

1. Construction: The engine jacket water shall be cooled through an integral tube and fin type radiator sized to provide full cooling of engine heat rejected to the coolant at 105 % of maximum load operation and a maximum external air flow restriction of 0.5" water. A blower type fan and all rotating members and drive belts shall be guarded and meet OSHA standards.
2. Coolant and Conditioner: The unit shall be provided with factory installed and tested 50% ethylene glycol Nalcool treatment shall also be added to the system in proper proportion.
3. Jacket Water Pump: Provide an integrally mounted jacket water pump of sufficient capacity to circulate jacket water through engine coolant system at a rate as required to provide full cooling of engine heat rejection to coolant at full load rated speed.

- E. Provide dual connection compression type lugs.
- F. Provide two (2) battery charges and two (2) battery racks.
- G. Exhaust System:
 - 1. Muffler
 - a. Provide a critical grade exhaust silencer, Maxim M41, as manufactured by Beaird Industries, Inc. or approved equal, properly sized by the manufacturer. The exhaust outlets on the engine shall be joined so there is only one common exhaust connection, one common flexible connection and one companion flange. Gaskets shall be furnished as required. Muffler shall be of double-walled, all welded construction protected by two single coats of shop primer.
 - b. Provide performance data for sound attenuation in dB in each of the eight octave band frequencies and 'A' scale attenuated exhaust noise with silencer at ten feet.
- H. Main Circuit Breaker shall be molded case, enclosure mounted on the generator, and be sized at 3000 amp, 150 AIC, 480 volts, and a 24 volt DC shunt trip. The circuit breaker enclosure shall be built to accept a flexible conduit, bottom entrance.
- I. Voltage Regulator: The voltage regulator shall be solid state, three phase sensing, volts per hertz type, to be supplied by the engine generator set manufacturer. Voltage drift shall be no more than $\pm 0.5\%$ of rated value at constant temperature. Adjustable controls for voltage drop, level and gain shall be easily accessible. Voltage level adjustment shall be a minimum $\pm 10\%$. Current limiting circuits shall be used to restrain exciter field current in the event of a sustained low power factor load. It shall provide rapid response during transient conditions. Overvoltage and undervoltage protection shall be provided along with a solid state circuit to remove excitation when generator overload for more than 10 seconds occurs. Telephone Influence Factor shall not exceed 50. At full throttle engine starting, output voltage shall not overshoot more than 5% of its rated value, with respect to the volts/Hz curve and response time shall be less than 20 milliseconds.
- J. Control Panel: A generator mounted solid state control panel with digital readout meters and self diagnostic capability shall be provided, shock mounted and vibration isolated on the generator. Control panel shall include 1% true RMS reading meters for amps, and volts, a phase selector switch (four position), frequency meter, voltage adjust rheostat, oil pressure gauge, water temperature gauge, battery DC voltmeter, tachometer, auto start-stop control module, overcrank, four position engine control switch for: Stop-Off/Reset-Manual-Auto, Cycle Cranking, Cooldown Timer, and Emergency Stop Push-button.
 - 1. Alarm module with flashing LEDs and horn to annunciate the following:
 - a. High coolant temperature alarm
 - b. Low coolant temperature alarm
 - c. Low oil pressure alarm
 - d. Battery Charger Malfunction
 - e. Generator on load
 - f. Low oil level
 - 2. Engine run contact
 - 3. All necessary control wiring, fuses, fuse blocks, terminal blocks, name- plates, fault contacts, auxiliary contacts, metering control transformers.

- K. Remote Annunciation Panel: A remote annunciator panel shall be provided with alarm indicating lights and alarm horn with test switch and silence button for the following alarm conditions:
1. Low oil pressure
 2. Overspeed Shutdown
 3. Battery charger malfunction
 4. Low coolant temperature
 5. Overcrank Shutdown
 6. Generator on Load
 7. Low oil level
- L. Foundation: The engine and generator shall be factory mounted on a torsionally stiff base, prime painted, fabricated from channel or I-beam to insure adequate mounting surface contact and minimal deflection.
- M. Vibration Isolator: Provide spring-type vibration isolators between engine structure and foundation pad. Quantity of isolators shall be furnished as required to provide the whole system (base, engine, generator) with proven compatibility and shall be certified as such by the manufacturer of the unit. Spring isolators shall be capable of 96% of transmitted vibration isolation, rated for a static deflection of 1" maximum, and suitable for seismic design appropriate for an importance factor of III (essential facility) and a ground motion acceleration as indicated in the International Building Code Sections 1614 and 1615. Seismic protection and vibration efficiency calculations shall be submitted for approval. Vibration Isolators shall be by Ace Mounting Co., Inc., Series 632, or approved equal.
- N. Power Generator: The power generator shall be of the single bearing type, 1800 rpm, 2000 kW, .8 pf, 60 Hz, 3 Phase, 4 wire, 480/227 V, PGM type. Subtransient reactance shall be a minimum of .20 per unit on the direct axis. The power generator shall be manufactured and packaged by the engine manufacturer to insure proper performance and affect a single source of responsibility. The generator shall be rated and conform to NEMA standards for temperature rise and construction. The unit shall be synchronous, tropicalized and built per NEMA MG I-22 and IEEE standards. Class F insulation shall be used on stator and rotor and both shall be protected with an asphalt modified epoxy on all end coils. The generator shall derive excitation current from the generator output. The AC power shall be converted and controlled by silicon-controlled rectifiers. The rotor assembly shall demonstrate 130% overspeed capability at 170° C for 2 hours. The generator rotor two plane dynamic balance shall be within 0.002" peak-to-peak amplitude displacement while at operating speed. The generator shall have a waveform deviation of not more than 5% and shall meet NEMA limits for telephone influence factors. Generator pitch shall be .6666. Power supply to the voltage regulator shall be by a separate permanent magnet generator (PMG).
- O. Automatic Starting System
1. A 24 volt DC electric starting system with positive engagement drive shall be furnished.
 2. Provide 24 volt Lead-Acid storage batteries of the heavy duty diesel starting type. The battery set shall be complete with steel rack, necessary cable and connectors, all in conformance with the engine manufacturer's requirements. Battery set shall be rated 244 amp hour capacity minimum.
 3. For maintenance of the batteries at 90% - 100% of full charge, a 20 amp minimum, automatic dual rate battery charger, as manufactured by LaMarche or approved equal, shall be provided. The charger shall recycle automatically to "on" or high rate at sufficient frequency to maintain high state of charge and long battery life. The charger shall be complete with DC ammeter, voltmeter, on-off switch, DC fuse, and charging indicator light. The 120 volt input to the charger shall be automatically disconnected during engine cranking cycle.
- P. Jacket Water Heater: Thermostatically controlled, jacket water heater, 480 V, single phase, 60 Hz, as per manufacturer's recommendations, with an oil pressure switch to shut down the water heater when the engine starts and flow of oil has been proven. It shall maintain engine coolant temperature at a minimum of 100° F in an ambient of 40° F. A contact shall close when jacket water temperature drops below 70° for remote alarm.

Q. A VAR/Power Factor controller shall be provided.

2.04 DAY TANK

- A. Provide a packaged design fuel oil day tank for each emergency generator. Day tank shall be complete in all respects in order to provide the generator with a reliable, local source of fuel. Tank assembly shall be complete in all respects in order to provide the generator with a reliable, local source of fuel. Tank assembly shall be in compliance with NFPA 30, 31, and 37 and in conformance with UL-142.
- B. Capacity: 300 gallons.
- C. Power requirements: 115 VAC, single phase, 60-Hertz, 15 A dedicated branch circuit.
- D. Day tank construction:
1. All welded steel atmospheric tank of rectangular construction, built in accordance with codes and standards noted above for indoor use with fuel oil.
 2. Pipe thread connections shall be provided for fuel oil supply from main tank, supply to prime mover, return from prime mover, overflow to main tank, vent, and drain with ball valve. The drain will penetrate the containment described below. A weatherproof, screened vent cap shall be provided as a loose item for field installation at the outdoor vent termination.
 3. An inspection port in the top shall be provided.
 4. The tank shall be equipped with a welded steel channel base suitable for bolt attachment to a concrete pad.
 5. The tank shall have interior corrosion protection consisting of an epoxy coating.
 6. The exterior of the day tank and the interior and exterior of the containment described below shall receive a heavy duty industrial anti-corrosion coating and be finish painting.
 7. All day tank system components shall be protected by a removable steel equipment cover.
 8. Day tank shall be factory leak tested at 5 psi.
 9. The tank shall be installed and anchored with a steel containment basin having a minimum capacity of 110% that of the day tank. The containment shall be protected against intrusion of debris and falling water. The containment shall be equipped with a leak detector that shall activate the "rupture" alarm. A drain with ball valve shall be supplied.
 10. The day tank shall be equipped with a solenoid valve 1.0 inch NPT, 100 psi, normally closed, under control of level controller. An inlet shut off valve shall be provided.
 11. Day tank level controller: Provide an electronic liquid level controller/indicator with functions to include: adjustable differential valve level control, tank level indication, system alarms, and manual operating controls. Level controller shall be self-contained as a unit and within a NEMA 1 box mounted on top of the day tank.
 12. The level controller shall provide the following:
 - a. Control Functions:
 1. "Auto-off-Manual" fill control mode switch
 2. "Press to Test" fill control pushbutton
 3. Adjustable differential valve level control with output contacts for control of on board solenoid valve and remote delivery.
 4. Overflow cutout.
 - b. Indication functions:
 1. Electric level gauge and condition indicator scaled in percent level, color coded and placarded to indicate system condition vs. level.
 2. LED lamp indicators for:
 - a. Power available
 - b. Fill control not in auto
 - c. Tank filling
 - d. Low level alarm
 - e. High level alarm
 - f. Tank rupture

- c. Outputs:
 - 1. Fill control start-stop
 - 2. Low level alarm
 - 3. High level alarm
 - 4. Not-in-auto
 - 5. Tank rupture
- 13. The level controller shall have an intrinsic overflow cutout back-up control which, upon sensing an overflow, will open the fill control contacts, close the fill control solenoid valve, and stop the remote fuel delivery system, activate an alarm and cause the controller to revert to an emergency back-up level control mode, which allows the tank to continue operating automatically, which inhibits overflow.
- 14. The level controller shall have a tank rupture cutout circuit which, upon sensing the presence of liquid in the tank containment, will open the fill control contacts, close the fill control solenoid valve, and stop the remote fuel deliver system and activate an alarm.

E. System testing:

- 1. The fuel supply system shall be supplied with manufacturer's test certificates as follows:
 - a. Tank test: Pressure test, leak-proof test, and structural integrity/appearance test.
 - b. Level controller: Operational test and calibration of level sensors, level indicator, level control, alarms, back-up devices.

PART III - EXECUTION

3.01 TESTING

A. The engine generator shall be tested at its point of fabrication and must comply with the following criteria:

- 1. Cold start acceleration to rated voltage and frequency within eight seconds.
- 2. Full and partial load applications and rejections during the test (at least two per hour). Frequency and voltage stability and transients shall not exceed the limits specified herein.
- 3. Fifteen minute, 1/4 load, or function warm-up; 1/2 hour, 1/2 load; 1/2 hour, 3/4 load, and one hour, full load; plus overloads if specified herein.
- 4. Demonstrate that all applicable safety shutdowns function along with their respective audio and visual alarms.
- 5. The engine manufacturer shall demonstrate that in the emergency condition, the unit is shut down due to lack of air.
- 6. Any defects found during the above test shall be corrected by the manufacturer at no expense to the purchaser.

B. Factory Assembly and In-Plant Test

- 1. Before shipment of the generator set equipment from the generator set manufacturer, the engine-generator set assembly shall be tested under full rated load and rated power factor (0.8 – Reactive) for performance and proper functioning of control and interfacing circuits. Tests shall include but not be limited to the following:
 - a. Engine Speed (RPM)
 - b. Engine Frequency
 - c. Average Voltage
 - d. Line-to-Line voltages for all three phases.
 - e. Average current
 - f. Line currents for all three phases

2. Full load bank test:
 - a. 4 hours at 50% load.
 - b. 4 hours at 75% load.
 - c. 8 hours at 100% load.
 - d. 50% step load transient response showing frequency and voltage variation and recovery time both for application of load and for removal of load. Test shall be repeated a minimum of four times.
 - e. 100% step load transient response showing frequency and voltage variation and recovery time both for application of load and for removal of load.
3. Factory testing shall be witnessed by the Owner's Representative, with two weeks notice being given before the start of such tests. Provide factory test reports at completion of testing to the Engineer.
4. Provide certified factory reports on all testing.

3.02 START-UP TESTING

- A. Engage equipment manufacturer's representative to perform start-up and building load tests upon completion of installation, with the Architect/Engineer in attendance. Provide certified test record. Tests are to include the following:
 1. Check fuel, lubricating oil, and antifreeze in liquid-cooled models for conformity to the manufacturer's recommendations under environmental conditions present. Torque and align radiator fan pulley and belt.
 2. Test prior to cranking engine for proper operation, accessories that normally function while the set is in standby mode. Accessories include: engine heaters, battery charger, generator strip heater, remote annunciator.
 3. Check, during start-up test mode, for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage, and phase rotation.
 4. Test, by means of simulated power outage, automatic start-up by remote-automatic starting, transfer of load and automatic shutdown. Monitor throughout the test, engine temperature, oil pressure, oil temperature, fuel consumption, battery charge level, generator voltage, amperes, and frequency.
- B. Upon completion of installation, demonstrate capability and compliance of system requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Initial testing and retesting to be at no cost to Owner.

3.03 ACCEPTANCE TESTS

- A. Acceptance testing will not start until start-up testing has been satisfactorily completed.
- B. The installed engine generator shall be fully load tested for a four hour period by means of resistive load banks. Each unit shall be continuously tested at 1/2 load for one hour, 3/4 load for one hour, and full load for two hours. Test shall show that no more than ten seconds elapse from the time of start signal from the switchgear and the acceptance of full load.
- C. A complete check of all safety and control circuitry, and instrumentation, and testing and chart recordings of the unit's winding and bearing temperatures, transient response characteristics, and vibration readings of the completed unit.
- D. 50% step load transient response showing frequency and voltage variation and recovery time both for application of load and for removal of load. Test shall be repeated a minimum of four times.

- E. 100% stop load transient response showing frequency and voltage variation and recovery time both for application of load and for removal of load.
- F. All tests will be done in conjunction with the automatic transfer switch manufacturer.
- G. System level tests will be done in conjunction with the automatic transfer switch manufacturer.
- H. Building final system tests will be in conjunction with all related manufacturers and needed personnel.
- I. The acceptance tests shall be performed under the supervision of a factory-trained representative of the equipment manufacturer. The tests shall be complete and follow the manufacturer's on-site test procedures. Results of the tests shall be on the manufacturer's standard test report forms. The certified report shall be given to the Construction Manager, with a copy to the Engineer, upon completion of the test.
- J. Engine generators that do not meet the test requirements shall be retested at no additional cost to the Owner. After successful completion of on-site tests, the lube oil and fuel-filter and air-filter elements shall be replaced and a lube-oil sample taken and analyzed.
- K. The vendor's bid shall include the necessary labor and material costs to perform all tests as specified.
- L. Site and acceptance testing shall be performed using on-site fuel oil system. Contractor shall top-off fuel after Owner has accepted system.

3.04 PERSONNEL TRAINING

- A. Building Operating Personnel training: Train Owner's building personnel in procedures for starting up, testing, and operating diesel engine-driven generator sets. In addition, train Owner's personnel in periodic maintenance of batteries. The material in the maintenance manuals specific to this site shall be reviewed in detail. Five training sessions (minimum six hours each) for up to six individuals shall be held at the Owner's site.

3.05 LOAD BANKS

- A. Temporary load bank (one required) for all testing shall be 2000 kW provided by generator manufacturer and wired by Electrical Contractor.

3.06 MAINTENANCE INSPECTION PROGRAM

- A. The bidders must offer, and submit with the bid, a maintenance inspection program complete with check list and sample report to be given to the Owner after each of the four quarterly visits. First year's inspection program to be included in equipment bid price. Future years program must be available at a reasonable cost to be negotiated.
- B. Bidders must submit with their Bid an itemized cost for the proposed maintenance program and for performing maintenance after the first four quarterly visits.
- C. The following inspection maintenance and operational checks will be made as a minimum. Maintenance shall be performed by authorized factory personnel only:
 - 1. Starting System
 - a. Clean batteries and cables
 - b. Check and record specific gravity of batteries.
 - c. Check for proper starter operation noting any unusual noises.
 - d. Inspect starter brushes and commutator.
 - e. Check for proper cranking motor disconnect.

- f. Load test the battery set.
- 2. Battery Charging System
 - a. Check battery trickle charger for proper operation.
 - b. Check battery charging alternator for proper output.
 - c. Tighten all battery connections.
 - d. Check electrolyte level and fill.
- 3. Fuel System
 - a. Check engine and supply system for any fuel leaks.
 - b. Check operation of day tank pump and float switch.
 - c. Check electrical and piping connections to day tank.
 - d. Check fuel pressure gauge for proper pressure.
 - e. Drain condensate from bottom of the day tank.
 - f. Take sample of diesel fuel for analysis (one per year).
- 4. Lube Oil System
 - a. Check oil level.
 - b. Check engine oil pressure.
 - c. Take sample of lube oil for analysis (one per year).
 - d. Change oil and oil filter at the end of the first year.
- 5. Air Intake System
 - a. Check air cleaner condition.
 - b. Check turbocharger for excessive end play.
 - c. Listen for any unusual noises from this area.
 - d. Check air intake louvers for proper operation.
 - e. Insure that air intake flow is not unduly restricted.
- 6. Exhaust System
 - a. Inspect exhaust silencer, flexible connection, and exhaust piping.
 - b. Visually check exhaust outlet for excessive smoking.
 - c. Visually check crankcase breather for excessive smoking.
 - d. Check the exhaust temperature of each cylinder with infra-red gun.
- 7. Cooling System
 - a. Check coolant level.
 - b. Check for proper amount of anti-freeze.
 - c. Check radiator core for obstructions or build-up of foreign matter.
 - d. Check general condition of engine coolant.
 - e. Repair any minor leaks.
 - f. Check all belts for wear and proper tension.
 - g. Check all hoses for cracks or brittleness.
 - h. Check thermostats for proper operation.
- 8. Speed Control System
 - a. Check governor rods and linkages for loose or worn parts.
 - b. Check governor operation under load.
 - c. Tighten loose wiring connections and note any potential problems.
- 9. Safety System
 - a. Test overspeed device.
 - b. Test water temperature contactor.
 - c. Test lube oil pressure contactor.
 - d. Test overcrank device.
 - e. Check out any other safety devices, of which we are aware, the failure of which may cause damage to the engine.
- 10. AC Power Generator
 - a. Make a general inspection of all electrical connections on regulator and generator.
 - b. Inspect generator brushes and sliprings, if applicable.
 - c. Grease bearings if necessary.
 - d. Check and adjust voltage regulator.
- 11. Engine Control Panel
 - a. Inspect all electrical connections and tighten where necessary.

- b. Inspect condition of relay contacts.
 - c. Thoroughly clean control panel.
 - d. Replace any indicator lights not working.
 - e. Replace any blown fuses.
 - f. Check operation of main circuit breaker and leave in "ready" position.
12. General
- a. Carefully inspect engine for leaks or deterioration.
 - b. Make note of any unusual sounds during walk-around inspection.
 - c. Check and adjust voltage and frequency.

END OF SECTION 16622

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 GENERAL**

- A. Furnish and install where indicated a 100 A, 480 V, 3 Phase, 3 Pole Automatic Transfer Switch (ATS) having the ratings, options, enclosures, etc. indicated on the drawings or noted herein. The automatic transfer switch shall be fully rated to protect all types of loads, inductive and resistive, from loss of continuity of power.
- B. The transfer switch shall automatically transfer its load circuit to an emergency or alternate power supply upon failure of its normal or preferred source.
- C. The transfer switch shall provide complete protection with field adjustable solid-state voltage sensing logic to monitor each phase of the normal power supply. The close differential adjustment shall be factory set to drop out when the monitored voltage drops below 70% of normal and initiate load transfer when the alternate standby source becomes available. Upon restoration of the normal source to a pick-up level of 90%, the logic shall initiate automatic re-transfer of the load circuits to the normal source.
- A. The transfer switch shall have withstand, closing, and interrupting ratings sufficient for the voltage and the available short circuit current at the point of application as shown on the drawings. The transfer switch shall be rated for application downstream of power circuit breakers and insulated case circuit breakers having short time delay settings of up to 30 cycles. The transfer switch should have a minimum interrupting rating of 42,000 AIC.
- D. The transfer switch shall be 100% equipment rated for continuous duty and shall conform to the applicable standards of UL 1008 for emergency total system load. All automatic transfer switches shall bear the UL label.
- E. The transfer switch shall have the option of being completely bypassed and isolated from the source and load.
- F. The transfer switch shall contain an in-phase monitor to prevent switching to an alternate source beyond pre-set phase tolerance.

1.02 STANDARDS

- A. The automatic transfer switch shall be designed, manufactured, tested, and installed in compliance with the following standards:
 - 1. NEMA ICS2-447
 - 2. NFPA 70 (NEC)
 - 3. NFPA 99
 - 4. NFPA 110
 - 5. UL 1008

1.03 SUBMITTALS

- A. Submit product data under provisions of Section 01340.
- B. Submit shop drawings of ATS indicating type, size and location of field connection.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers for the Automatic Transfer Switch are as follows:

1. Caterpillar
2. GE Zenith
3. ASCO
4. Cummins/ Onan
5. Russelectric

2.02 DESCRIPTION AND OPERATION

- A. The transfer switch shall consist of completely enclosed contact assemblies and a separate control logic panel. The contact assemblies shall be operated by a non-fused unidirectional motor operator or stored energy mechanisms, and be energized only momentarily during transfer providing inherently double throw switching action. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.
- B. Transfer switch shall be capable of being operated manually under full load conditions. Manual operation shall be accomplished via a permanently affixed manual operator or integrally mounted push button operators located on the face of the contact assemblies. Removable manual operating handles and handles which move in the event electrical operators should suddenly become energized while performing a manual transfer operation are not acceptable. The manual operator shall provide the same contact-to-contact transfer time as provided under normal automatic operation to prevent possible flashover from switching the main contacts slowly. In addition, provisions shall be provided to allow disengagement of the electrical operator during manual operations.
- C. The transfer switch shall be positively interlocked, both mechanically and electrically, to prevent simultaneous closing of both sources under either automatic or manual operation. The transfer switch shall have a manual neutral position for load circuit maintenance. A transfer switch position indicator shall be visible from the front of the switch to show to which source the transfer switch is connected.
- D. Inspection and replacement of all separate arcing contacts (moving and stationary) shall be possible from the front of the transfer switch.
- E. A solid-state sensing and control logic panel shall be separately mounted from the power-switching portion of the transfer switch. The two sections shall be connected together by control cables with plug-in connectors. The control section shall be capable of being disconnected from the power section for maintenance purposes.
- F. The logic circuit shall utilize solid-state components mounted on printed circuit boards to accomplish functions such as timing, time delays, and voltage and frequency monitoring. LEDs shall be furnished to indicate the operation of each solid-state function furnished. Construction shall be such that functions are individually replaceable without requiring replacement of the complete solid-state package. Plug-in modifications shall be available for field installation without voiding the UL label.
- G. The transfer switch shall be equipped with a voltage selection plug making it suitable for operation on any voltage from 208 through 600 volts AC, 50 or 60 Hertz, by placing the voltage selection plug in the proper voltage receptacle. Covers shall be used to block off the unused receptacles.
- H. All pilot devices and relays shall be industrial type rated 10 amperes with self-cleaning contacts.
- I. The transfer switch shall not be capable of being completely bypassed and isolated from the load.

2.03 ACCESSORIES

A. The following accessories shall be provided:

1. Time delay normal to emergency, adjustable 1 to 60 seconds.
2. Time delay emergency to normal, adjustable .2 to 30 minutes.
3. Green pilot light to indicate switch in normal position and red pilot light to indicate switch in emergency position.
4. White pilot lights marked "Normal Source" and "Emergency Source" to indicate that respective source voltage is available.
5. Exerciser (seven days from initial command).
6. Hand-held kit for field test and calibration of all plug-in timing and monitoring cards, as well as the output relays from the solid-state logic.
7. Frequency/voltage relay for emergency source, frequency adjustable 45-60 Hz and voltage fixed 90% pick-up, 70% drop out.
8. Four position selector switch to provide "Test", "Auto", "OFF", "Engine Start". Furnish white pilot light for "OFF" indication.
9. All indicating lights shall be long-life LEDs.
10. Remote transfer initiate option.
11. Remote load shed control.
12. Adj. 0.5-3 second time delay on engine start.
13. Load-No load test switch.
14. One contact to open and one contact to close on failure of normal to be used for engine starting.
15. Block transfer control relays to inhibit transfer to the emergency position when signaled by the generator control.
16. Relay contacts (6 NO/6 NC) for additional monitoring purposes to be determine during review of shop drawings.
17. In-phase monitor.

PART III - EXECUTION

3.01 INSTALLATION

- A. Install ATS in accordance with manufacturer's requirements.
- B. Install ATS in first floor as indicated on the drawings.

3.02 SET-UP AND TESTING

- A. Coordinate set points for ATS with UPS to ensure UPS accepts alternate source when utility is out-of-spec.
- B. Provide written start-up report indicating set points.

END OF SECTION 16623

PART I - GENERAL1.01 SYSTEM CONSIDERATIONS

- A. This specification defines the electrical mechanical characteristics and requirements for a Parallel Design Surge Suppression System. The Distribution Panel Protector, hereafter referred to as TVSS (Transient Voltage Surge Suppressor) or SPD (Surge Protective Device), shall include everything required to properly interface with the service entrance or distribution panel. The units shall also have integral disconnect switches.
- B. General Characteristics:
1. One (1) each SPD shall be provided in MSA, MSB, UPSSA & UPSSB with the following characteristics (similar to Liebert Interceptor II)::
 - a. Non-Service entrance rated
 - b. Nominal Line Voltage: 480, 3 ph, 3 wire from grounded neutral at upstream transformer.
 - c. Category – C3
 - d. Maximum surge current per mode = 100 ka, L-G, L-N, N-G
 - e. Maximum surge current per phase = 200 ka
 - f. Minimum repetitive surge current capacity/mode = 6,000
 2. One (1) each SPD shall be provided for ACDPA, ACDPB, ACDPA1, ACDPB1, LPA, and LPB with the following characteristics (similar to Liebert ACCUVAR):
 - a. Non-Service entrance rated
 - b. Nominal Line Voltage: 480v, 3 ph, 3 wire from grounded neutral upstream transformer.
 - c. Category – C
 - d. Maximum surge current per mode = 80 ka, L-G, L-N, N-G
 - e. Maximum surge current per phase = 160 ka
 - f. Minimum repetitive surge current capacity/mode = 3,000

1.02 SYSTEM REQUIREMENTS

- A. System electrical requirements
- B. Voltage: System voltage shall be 480 volts AC, 3 – Phase, 3 - wire, plus ground. Upstream transformer is a 480/277V source.
- C. Frequency: Nominal system operating frequency shall be 60 Hz

1.03 SYSTEM ENVIRONMENTAL REQUIREMENTS

- A. Operating Temperature: The TVSS shall be designed for operation in ambient temperatures of -40° C to 85° C (-40° F to 185° F).
- B. Relative Humidity: The relative humidity of the environment for the TVSS shall be within the range of 5% to 95 % non-condensing.
- C. Operating Altitude: The TVSS shall operate at an altitude of up to 12,000 feet.

1.04 APPLICABLE STANDARDSSTANDARDS

- A. The TVSS shall be designed, manufactured, tested and installed in compliance with the following standards:

1. Underwriters Laboratories (UL)
 2. National Electrical Code (NEC)
 3. National Fire Protection Association (NFPA)
 4. American National Standards Institute (ANSI)
 5. Institute of Electrical and Electronics Engineers (IEEE)
 6. Military Standards (MIL-STD-220A)
 7. Federal Information Processing Standards Publication 94 (FIPS Pub 94)
 8. Local codes having jurisdiction
- B. Testing Standards: The TVSS shall be tested to and comply with the following:
1. UL 1449 – Second Edition; effective February 16, 1998, Standard for Safety for Transient Voltage Surge Suppressors.
 2. ANSI/IEEE C62.41, Recommended Practice for Surge Voltages in Low Voltage AC Power Circuits.
 3. NEMA LS-1, Specification Format for Low Voltage AC Surge Protective Devices (1000 volts or less).
 4. CSA –C22.2 and NOM Approvals for TVSS.
 5. Total system shall be tested to MIL-STD-220A.
- C. UL: The TVSS shall use only UL-recognized protection modules and components. System shall be UL listed.

PART II - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are as follows:

1. L.E.A. International
2. Leviton
3. Liebert
4. United Power
5. Current Technology

2.02 SYSTEM COMPONENTS

- A. General: The TVSS shall be of a parallel, multi-staged hybrid design. The TVSS shall use fast-acting, high-energy dissipaters and transient-energy protectors that will divert and dissipate the surge energy. The TVSS shall be self-restoring and fully automatic, with a total system response time not to exceed 5 nanoseconds. The TVSS shall include an integrated status alarm monitor circuit, surge counter, and audible alarm to facilitate a positive diagnosis of continuous operation.
- B. High-Energy Dissipater (HED): The primary protection shall be high-energy associated with a lightning strike. The HED shall be connected Phase to Ground, providing maximum lightning protection with a surge current capacity of 200,000 amps/module with an 8 x 20 microsecond test waveform. The HED shall incorporate fuse links that, if the surge capacity of the module is exceeded, will disconnect the HED from the AC source without interrupting power to the load.
- C. Transient-Energy Protector (TEP): The secondary protection shall be a solid-state clamping network, capable of clamping impulse voltages, regardless of their origin, to the specified safe level. The TEP shall be installed phase to phase (delta), providing maximum protection against surges and spikes with a surge current capacity of 200,000 amperes/module with an 8 x 20 microsecond test waveform. Component response time shall be 1 picosecond. Total module response time not to exceed 5 nanoseconds.

- D. Status Indicators: The TVSS shall include redundant status indicators, providing a continuous positive indication of TVSS protection module status.
- E. Status Alarm Monitor (SAM): The TVSS shall include a status alarm monitor system, which will continuously monitor each phase of the incoming power as well as the status of the TEP and HED modules. The SAM shall include Normally Open (N/O) or Normally Closed (N/C) dry contacts. The SAM shall also serve as the single monitoring device for connection to all other monitoring devices as listed below. The SAM shall incorporate its own transient voltage suppression network to protect itself from damage due to surge and transient energy. Two SAM modules are required.
- F. Surge Counter Option (SCO): The TVSS shall include a surge counter, on the face of the enclosure, which will count all transients occurring above the system clamping voltage threshold. The SCO shall interface with the SAM system and be independently powered without using an external power supply. The SCO shall maintain data in the event of a power failure or disconnection from the AC power source. The SCO system shall provide a visual count of all surges and transients through LCD readout. The SCO circuitry shall prevent incorrect counting of ringing transients by registering all surges and transients occurring within 20 milliseconds as a single event. The SCO shall be capable of being reset by a push button switch on the surge counter meter face plate.
- G. Audible Alarm (AAO): the TVSS shall include a solid-state audible alarm, which will sound in the event that any protection module fails. The AAO shall include an enclosure mounted transducer and lighted on/off alarm silence switch with visual indication of silence selection. The AAO will interface and derive its power solely from the SAM board. No additional power supply source will be used.

2.03 ELECTRICAL SPECIFICATIONS

- A. The TVSS shall meet or exceed the following specifications:

- 1. Voltage Configuration: 480 volts AC, 3 – Phase, 3 - wire plus ground
- 2. Protection Configuration: Phase to phase (delta) and phase to utility common point earth ground
- 3. Maximum Surge Current/Phase: 200,000 amps
- 4. Response Time: total system response time not to exceed 5 nanoseconds
- 5. Minimum Energy Handling Capability/Phase: 10,000 joules
- 6. EMI/RFI Noise Rejection: 50 dB (50 Ohm insertion loss measurement method)
- 7. Clamping Voltage Ratio: Maximum clamping voltage ratio shall be 27:1 under test procedures outlined in ANSI/IEEE C62.41-1980, Category C, 8 x 20 uS at 10,000 amperes.
- 8. Performance: The TVSS shall be tested in accordance with procedures outlined in ANSI/IEEE C62.41-1980. Surges will be applied in all possible combinations; common mode to common mode, normal mode to common mode, normal mode to normal mode, and common mode to normal mode. The manufacturer shall provide certified test data consisting of specified clamp voltages and surge current capacity for category "C". Test shall be conducted as follows:

Category C - Biwave 8 x 20 uS at 10,000 amperes
 1.2 x 50 uS at 6,000 volts

In addition, the system design shall be life tested to withstand 6,000 sequential category C surges without internal failure. The TVSS shall also be tested to MIL-STD-220A for noise insertion loss in a 50 Ohm system for RF frequencies up to 400 MHz.

PART III - EXECUTION

3.01 GENERAL MECHANICAL REQUIREMENTS

- A. Termination: The TVSS shall include provisions for input termination. The method of wire connection shall utilize ANSI/NFPA 70-1987, NEC standard wiring practices.

B. Factory Testing: The TVSS shall be completely factory tested before shipment. Testing shall include, but not be restricted to, the following:

1. Quality Control Checks
2. MIL-STD-220A
3. ANSI/IEEE C62.41-1980: Category A, Category B, Category C

3.02 DRAWINGS

A. The manufacturer shall provide detailed mechanical and electrical drawings, showing component location and electrical connections for installation.

3.03 INSTALLATION

A. Install TVSS plumb and level where indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products fulfill requirements.

END OF SECTION 16670

***** PRE-PURCHASED EQUIPMENT *******PART I - GENERAL****1.01 SYSTEM CONSIDERATIONS**

- A. This specification defines the electrical characteristics and requirements for a battery monitoring system.

1.02 SYSTEM REQUIREMENTS

- A. System electrical requirements: 120 Volt, 20 Amp, 2 wire plus ground.
- B. Frequency: Nominal system operating frequency shall be 60 Hz.

1.03 SYSTEM ENVIRONMENTAL REQUIREMENTS

- A. Operating Temperature: The system shall be designed for operation in ambient temperatures of -40° C to 85° C (-40° F to 185° F).
- B. Relative Humidity: The relative humidity of the environment for the system shall be within the range of 5% to 95 % non-condensing.

1.04 APPLICABLE STANDARDS

- A. The battery monitoring system shall be designed, manufactured, tested and installed in compliance with the following standards:
1. Underwriters Laboratories (UL)
 2. National Electrical Code (NEC)
 3. National Fire Protection Association (NFPA)
 4. American National Standards Institute (ANSI)
 5. Institute of Electrical and Electronics Engineers (IEEE)
 6. Military Standards (MIL-STD-220A)
 7. Federal Information Processing Standards Publication 94 (FIPS Pub 94)
 8. Local codes having jurisdiction

PART II - PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Acceptable manufacturers are as follows:
1. Alber
 2. B-Tech
 3. Cellwatch

2.02 SYSTEM COMPONENTS

- A. General: The battery monitoring system shall be a solid state, automatic battery monitor for two (2) separate battery systems consisting of 240 cells with two cells per jar. All conditions shall be monitored and alarmed locally via a wall-mounted panel in the battery room and remote at a Windows-based PC. The monitoring system shall include the following as a minimum:
1. Condition of the batteries: A print-out shall be provided every time a battery discharge takes place.

2. The unit shall indicate the battery system's capability to carry the load and indicate if additional load can be added without risking battery failure.
3. Record of Battery Usage:
 - a. Date and time when discharge took place
 - b. Duration of discharge
 - c. Load during discharge
 - d. Battery system voltage during discharge
 - e. Ambient temperature at start of discharge
 - f. Total accumulated number of discharges, lasting 30 seconds or less
 - g. Total accumulated number of discharges, lasting in excess of 30 seconds, but less than five minutes.
 - h. Total accumulated number of discharges, lasting five minutes or more.
 - i. Total accumulated battery discharge time (minutes).
 - j. Total accumulated battery discharge kW hours.
4. Battery Charger Performance - Ambient Temperature
 - a. Battery float voltage and charger current printed every 24 hours.
 - b. Battery room ambient temperature printed every 24 hours.
 - c. Recharge current and voltage printed during initial recharge period.

2.03 PERFORMANCE CHARACTERISTICS

A. The battery monitor shall have the following performance characteristics:

1. Alarms: Standard:
 - a. Flashing LED and beeper, discharge activated
 - b. Dry contact for remote sensing: 1A, 120 VAC
 - c. Under Voltage during discharge
 - d. Over Current during discharge
 - e. Over Voltage during discharge
 - f. High/Low Temperature
2. Voltage: System level, maximum 800 VDC, 3 digit $\pm 1/2\% + 2$ digits.
3. Current: System level or individual parallel strings up to 3 strings, maximum 7000 A (1000 A probe), 4 digit $\pm 3\%$ scale.
4. Temperature: Degrees C and Degrees F (print degrees C), ± 1 degree C.
5. Charge/Discharge Sensors
 - a. Voltage detector (set for number of cells connected)
 - b. Current detector (set for +12 A charge, -30 A discharge)
6. Daily System Status (Automatic printout): Unit number, date, time, voltage, current, temperature.
7. Discharge Event (Automatic printout): Unit number, date, time, temperature, followed by elapsed time, voltage, and current at 1, 2, 5, 10, 20, 30, 40, 60 seconds, plus at each pre-selected time interval based upon support time.
8. Recharge (Automatic printout) Elapsed time, volts, and amps for three time intervals.
9. Cycle Counter (Test Print, non-automatic printout): Unit number, date, time, temperature, total accumulated number of battery discharges, total accumulated battery discharge time (minutes), and battery discharge kW hours.

B. The system shall include a monitored internal Nicad battery, permitting three hour operation of monitor during loss of AC power input.

2.04 BATTERY MONITORING SYSTEM SOFTWARE

A. System software, running on a window-based computer, shall communicate with the battery monitoring system via telephone or dedicated 2 twisted pair lines to acquire and archive the measured data, recall and sort it, print and/or plot it, and facilitate the observance of trends in the data which signify deteriorating conditions, allowing remedy before actual failure occurs. The software shall also provide the capability of remotely changing preset alarm thresholds. The system shall utilize a

password that must be entered prior to making programming changes. The password rule is applicable when interfacing with the monitor keypad or remotely via a PC keyboard.

- B. The system software shall be capable of managing multiple battery monitoring systems and be able to auto poll each system on a programmed schedule.

PART III - EXECUTION

3.01 GENERAL MECHANICAL REQUIREMENTS

- A. Cabinet: The battery monitoring system unit shall be housed in a single NEMA 12 type enclosure.
- B. Cooling: The battery monitoring system cabinet shall be a convection air-cooled type.
- C. Termination: The battery monitoring system shall include provisions for battery cable input termination. The method of wire connection shall utilize ANSI/NFPA 70-1987, NEC standard wiring practices.
- D. Factory Testing: The battery monitoring system shall be completely factory tested before shipment.

3.02 DRAWINGS

- A. The manufacturer shall provide detailed mechanical and electrical drawings, showing component location and electrical connections for installation.

3.03 INSTALLATION

- A. Install conduit and wiring in accordance with manufacturer's written instructions.
- B. Test system upon completion.

END OF SECTION 16671

PART I - GENERAL1.01 SCOPE OF WORK

- A. Provide a complete lightning protection system as shown on the drawings and as specified herein. The system shall be installed by a firm actively engaged in the installation of Master Labeled Lightning Protection Systems and shall be so listed by Underwriters Laboratories Inc.

1.02 REFERENCES

- A. The completed system shall comply with the latest editions of the Installation Requirements for Lightning Protection Systems, UL96A and the National Fire Protection Association's Lightning Protection Code, NFPA 780.

1.03 SUBMITTALS

- A. Submit shop drawings and product literature under provisions of Section 01300.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

- A. Harger Lightning Protection, Inc.
- B. Or approved equal

2.02 MATERIALS

- A. All materials used in the installation shall be labeled or listed by Underwriters Laboratories Inc. for use in Master Labeled lightning protection systems.
- B. Generally all materials shall be of copper and/or copper-bronze. In locations where system components are mounted on aluminum surfaces, aluminum materials shall be used to avoid electrolytic corrosion of the dissimilar metals.
- C. Materials shall be sized in accordance with the material requirements of NFPA-780 and UL96A. Class I materials shall be used.

2.03 AIR TERMINALS

- A. Air terminals shall project a minimum of ten inches above the area protected and shall be located at intervals not exceeding 20'-0" along ridges and around the perimeter of flat or gently sloping roofs. Flat or gently sloping roofs exceeding 50'-0" in width shall be protected with additional air terminals located at intervals not exceeding 50'-0" in the flat or gently sloping area. Air terminals shall be located within two feet of roof edges and outside corners of protected areas. Air terminal spacings exceeding these dimensions are permitted so long as the area protected lies within a zone of protection.
- B. Air terminals shall be installed for stacks, flues, mechanical equipment, and other objects not located within a zone of protection. Non-metallic objects or metal objects having a metal thickness of less than 3/16" require the installation of air terminals and required conductors. Objects having a metal thickness 3/16" or greater shall be connected to the lightning protection system per code requirements using main size conductor and connector fittings having 3 square inches of surface contact area.
- C. Air terminal mounting bases shall be of cast construction and securely fastened to the structure in accordance with code requirements.

2.04 CONDUCTORS

- A. Main conductors shall be sized in accordance with the material requirements above and shall provide a two-way path from each air terminal horizontally or downward to connections with ground terminals. Conductors shall be free of excessive splices and sharp bends. No bend of a conductor shall form an included angle of less than 90 degrees nor have a radius of bend of less than 8 inches. Conductors shall be secured to the structure at intervals not exceeding 3'-0".
- B. Down conductors shall be of copper and shall be concealed in the exterior wall construction. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure. In no case shall a structure have fewer than two down conductors.
- C. In the case of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the perimeter of the structure. Connections to the steel frame shall be made with bonding plates having 8 square inches of contact or by exothermic weld connections.

2.05 ROOF PENETRATIONS

- A. Roof penetrations required for down conductors or for connections to structural steel framework shall be made using thru-roof assemblies with solid bars and appropriate roof flashing. Conductors shall not pass directly through the roof. Roof flashing compatible with the roofing system shall be furnished and installed by the roofing contractor.

2.06 EQUAL POTENTIAL GROUNDING (Common Grounding)

- A. Common grounding of all ground mediums entering the building shall be ensured by interconnecting to the system using main size conductors and fittings.
- B. Grounded metal bodies located within the required bonding distance as determined by the bonding distance formulas in Section 3-23 of NFPA-780 shall be bonded to the system using bonding connections and fittings.

2.07 GROUND TERMINATIONS

- A. Ground electrodes shall be provided for each down conductor and shall consist of 5/8" x 10'-0" (minimum) copper-clad ground rod. The down conductor shall be connected to the ground rod using a bronze ground rod clamp having at least 1-1/2" of contact between the rod and the conductor, measured parallel to the axis of the rod, or by an exothermic welded connection. Ground rods shall be located 2 feet below grade, preferably 2 feet from the foundation wall and shall extend a minimum of 10' vertically into the earth.
- B. Where the structural steel framework is utilized as main conductors for the system, perimeter columns shall be grounded at intervals averaging not more than 60 feet apart. Columns shall be grounded using bonding plates having 8 square inches of surface contact area or by exothermic welded connections. Conductors from the ground connections to the ground termination shall be Class II copper lightning conductors.

PART III - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's requirements.

3.02 CERTIFICATION

- A. Upon completion of the installation, the contractor shall furnish the Master Label issued by Underwriters Laboratories Inc. for this system.
- B. If the protected structure is an addition to or is attached to an existing structure that does not have a lightning protection system, the contractor shall certify that the system installed complies with UL requirements and advise the Owner of the lightning protection work required on the existing structure to obtain the Master Label. If the existing structure does have a lightning protection system, the contractor shall advise the Owner of any additional work required on the existing system to bring it into compliance with current UL requirements and thus qualify for the Reconditioned Master Label of Underwriters Laboratories, Inc.

END OF SECTION 16675

PART I - GENERAL1.01 PROVISIONS

- A. Install an Emergency Power Off system in the data center for all air conditioning units, computer power centers, and panels as shown in the drawing.

1.02 RELATED REQUIREMENTS

- A. In addition to the sections listed below, all provisions of the contract including Division 1 apply to work specified herein.
- B. All sections under Division 15 that are related to the operation of the EPO system for mechanical equipment to shut-off.
- C. Section 16010: General Requirements for Electrical Work
- D. Section 16110: Raceway System
- E. Section 16120: Wires and Cables

1.03 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacturing of EPO station equipment and relays of ratings required and whose products have been in satisfactory use in similar service for not less than five years.

1.04 SUBMITTALS

- A. Submit manufacturer's information on all components used in the EPO system, including pull stations, relays, cabinets, etc.

PART II - PRODUCTS2.01 EQUIPMENT

- A. EPO Station: Momentary Contact, 10 AMP, 125V single pole, red and aluminum finish with NEMA Type-2 enclosure. Provide a protective cover-plate (equal to Safety Technology International, Inc.) to each EPO station to protect the system from unwanted EPO activation. Cover plate shall be marked as "Emergency Power Off."
- B. Relays: Relays shall be Industrial Type, 300V, 10 AMP rated with 8 poles, 120 VAC Coil, with the contacts convertible from normally open (N.O.) to normally closed (N.C.).
- C. Relay Cabinet: Provide a relay cabinet for EPO system to install the relays and controls in NEMA-1 enclosure.

PART III - EXECUTION3.01 INSTALLATION

- A. Install the EPO stations and EPO relays as shown on the drawings. Coordinate with adjacent equipment and structure to maintain proper working clearances.
- B. EPO system wiring shall be #12 AWG copper THHN minimum unless noted otherwise on drawing. Conduit shall be 3/4" minimum EMT, unless noted otherwise on drawing.

3.02 OPERATION

- A. EPO stations shall control equipment in the computer room and other areas as noted on the drawings. Activation of any station shall shut down all data processing equipment and A/C units in the computer room via the remote shutdown function available in the computer power centers, power distribution units and computer-grade air-conditioning units. For other miscellaneous mechanical items (fans, dampers, etc.), the EPO can be achieved through interlocks or shunt trips.
- B. EPO stations may also be provided to control equipment in the electrical switchgear, UPS and generator rooms. Activation of this station shall shut down the equipment as noted on the drawings.
- C. The EPO system shall be interfaced with the building fire alarm system. Coordinate with the building fire-alarm contractor for all zones that are required to be interfaced with the EPO system.

3.03 TESTING

- A. Test all the EPO stations. Testing shall be coordinated with the owner's representative and may require work on weekends or after normal working hours.
- B. A full report of all tests, inspections, and certifications shall be presented to the owner's representative and the engineer, ten working days after test completion.

END OF SECTION 16710

PART I - GENERAL1.01 RELATED SECTIONS

- A. Section 15340: Pre-action Sprinkler
- B. Section 15505: HFC-125 (FE-25) Suppression System

1.02 REFERENCES

- A. NFPA 70 - National Electrical Code.
- B. NFPA 72 - National Fire Alarm Code.
- C. NFPA 101 - Life Safety Code

1.03 SYSTEM DESCRIPTION

- A. The fire alarm system shall be a microprocessor based control system suitable for use as a local fire alarm system with releasing device service using automatic and manual initiating devices.
- B. The system shall provide an 80 character LCD display to indicate all information associated with the Fire Alarm condition, including type of alarm and location within the protected premise.
- C. The system shall provide a nonvolatile history buffer to log the time and date of each occurrence. The history buffer shall be large enough to log all potential alarms without losing any alarm initiations.
- D. The system shall activate all control functions within three seconds after receipt of alarm condition.
- E. All components shall be U.L. Listed and/or F.M. approved for the intended application.
- F. All components furnished shall be guaranteed against defect in design, material and workmanship for a period no less than one year provided documented proof of a service contract by an authorized service contractor covering the full warranty period is provided upon acceptance of the installation.

1.04 SUBMITTALS

- A. General
 - 1. Submit under the provisions of Section 01340.
 - 2. All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent equipment from other manufacturers may be substituted for the specified equipment as long as the minimum standards are met.
 - 3. For equipment other than specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance and quality of the specified equipment.
- B. Manufacturer's Product Data Sheets.
 - 1. Material and equipment information shall include manufacturer's catalog data sheets and any pertinent technical data for each component or device used on the system. This shall include the following:
 - a. Control panel
 - b. Analog smoke sensors

- c. Manual discharge stations
- d. Abort stations
- e. Contact monitoring devices
- f. Releasing Devices
- g. Addressable relays
- h. Addressable supervised output modules
- i. Graphic Annunciator

C. Shop Drawings

- 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
- 2. Include manufacturer's name, model numbers, ratings, power requirements, equipment layout, device arrangement, complete point-to-point wiring diagrams and conduit layout.
- 3. Complete sequence of operation for all control functions provided by the fire alarm control panel.
- 4. Show annunciator layout, configuration and terminations.
- 5. Voltage drop calculations for each cable run.
- 6. Battery sizing calculations with a minimum 25% spare capacity.

D. Manufacturer's Installation Instructions

- 1. Submit simultaneously with shop drawings, complete operating and maintenance manual.
- 2. Indicate application conditions and limitations of use stipulated by product testing agency.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit under the provisions of Section 01340.
- B. Record actual locations of all initiating devices, signaling appliance, end-of-line devices.
- C. Record actual wiring terminations.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under the provisions of Section 01340.
- B. Operating instructions shall be provided.
- C. Maintenance procedures shall be provided.

1.07 QUALIFICATIONS

- A. Manufacturer:
 - 1. Company specializing in the manufacturing the products specified in this section for at least ten years.
 - 2. The name of the manufacturer, part numbers and serial number shall appear on all major components.
 - 3. All devices, components and equipment shall be the products of a single manufacturer.
 - 4. All devices, components and equipment shall be new and standards products of the manufacturer's latest design, suitable to perform the functions intended.

B. Installation Firm:

1. The system shall be installed by an experienced firm regularly engaged in the installation of systems similar to those specified in this section. The firm shall have a minimum of five years experience in design, installation, testing and service of fire detection and control systems.
2. The installer shall be trained and certified by the manufacturer to design, install, test and service the fire detection and control system provided under this section.
3. The installation firm shall employ a NICET certified fire alarm system designer, level 2 or above, who will be responsible for this project.
4. The installation firm shall show evidence of a minimum \$2,000,000 liability and completed operations insurance policy. These limits shall supersede limits required elsewhere in this specification.
5. The installation firm shall provide proof of emergency service available 24 hours a day, seven days a week.

1.08 REGULATORY REQUIREMENTS

- A. System shall conform to the requirements of NFPA 70, NFPA 72, and NFPA 101.
- B. Furnish products listed and classified by Underwriter's Laboratory Inc. and/or Factory Mutual Research Corporation as suitable for the purpose specified and indicated.
- C. System shall conform to the requirement acceptable to the authority having jurisdiction.

1.09 MAINTENANCE SERVICE

- A. Furnish service and maintenance of the fire detection and control system for a period of one year from the Date of Substantial Completion.
- B. All labor and material required to maintain the system shall be included in this contract. Any perishable item supplied, such as batteries shall be exempt from this requirement if indicated in the submittal documents.

PART II - PRODUCTS2.01 MANUFACTURERS

A. Acceptable Manufacturers are as follows:

1. Edwards
2. Simplex
2. Honeywell
3. Notifier

2.02 CONDUIT AND WIRE

A. Conduit

1. Conduit shall be installed in accordance with the National Electric Code, NFPA 70.
2. All wiring shall be installed in a conduit or raceway. Conduit fill shall not exceed 40 percent of the interior cross sectional area where three or more cables are included within a single conduit.
3. Cables must be separated from any open conductors of Class 1 circuits and shall not be placed in any conduit, junction box or raceway containing Class 1 cables.
4. Wiring for low voltage control, alarm notification, emergency communication and similar power-limited auxiliary functions may be installed in the same conduit as initiating and signaling line

circuits. The system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

5. Conduits shall not enter the control panel or any other component provided except where entry is specified by the manufacturer.
6. Conduit shall be 3/4 inch minimum.

B. Wire

1. All fire alarm system wiring shall be new.
2. Wiring shall comply with local, state and national codes and as recommended by the manufacturer. Number and size of conductors shall be as recommended by the manufacturer, but shall be not less than 18 AWG for initiating device and signaling line circuits, and 14 AWG for notification appliance circuits.
3. All wiring and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
4. All field wiring shall be supervised for open circuits, short circuits and grounded conditions.

- C. The control panel shall be connected to a separate dedicated branch circuit with a separate dedicated disconnect switch. This circuit shall be labeled FIRE ALARM.

2.03 MAIN FIRE ALARM CONTROL PANEL (FACP)

- A. The FACP shall be a microprocessor based system capable of communicating with the following types of peripherals and accessories: smoke sensors, thermal sensors, contact monitoring modules, addressable supervised output modules, addressable releasing modules and addressable relay modules.

B. System Capacity and General Operation

1. The system shall be capable of communicating and controlling up to 508 addressable analog devices and sensors. The system shall support up to 240 software zones for configuring initiating devices and output functions.
2. The system shall respond to an alarm initiating device, including analog smoke sensors within 3 seconds for a fully loaded system (508 devices). Response times shall be measured from the activation of the initiating device to the activation of the associated notification appliance circuit.
3. The system shall provide an Alarm, Trouble and Supervisory Form-C Relay contact rated at a minimum of 2.0 amps @ 30VDC.
4. The system shall provide two configurable notification appliance circuits at the FACP. Each circuit shall be rated for 2.0 amps @ 24 VDC.
5. The FACP shall include a full featured operator interface control and annunciation panel that shall include a LCD display, individual color coded system status LEDs and an alpha numeric keypad for field programming of the fire alarm system.
6. All programming or editing of the existing configuration program in the system shall not require use of special equipment, such as a laptop personal computer. Access to the configuration program shall be limited by use of a password security system. Three levels of access shall be used to isolate user, maintenance and configuration operating portions of the system.
7. The FACP shall provide the following features:
 - a. Drift compensation for analog sensors.
 - b. Sensitivity test in accordance with NFPA 72 requirements.
 - c. Maintenance alert for sensors with excessive accumulations of dust or dirt.
 - d. Alarm verification with individual counters for each sensor.
 - e. Periodic calibration of smoke sensors.
 - f. Day/Night automatic smoke sensor sensitivity adjustments.
 - g. One man walk test with optional notification appliance testing.
 - h. Two levels of adjustable pre-alarm for advanced warning.
 - i. 1800 event history buffer, with dedicated 600 event alarm event buffer.

- C. Central Microprocessor: The central microprocessor shall communicate, control and monitor all external devices. All custom operating parameters for the system shall be stored in nonvolatile memory to prevent loss during power outages. A real time clock shall be provided to denote actual time of occurrence of system events for the display, history buffers and external reporting devices.
- D. Display
1. An 80-character LCD display shall annunciate system conditions and program system operating parameters.
 2. Eight status LEDs; AC Power, Fire Alarm, Pre-Alarm Warning, Supervisory, Trouble, Alarm Silence, Supervisory Silence and Trouble Silence, shall be provided.
 3. The display unit shall provide a 25 key-pad with tactile feel membrane switches that provide operational feedback. Separate keys shall be dedicated to System Reset, Step, Alarm Silence, Acknowledge, and Drill. The key-pad shall be used to provide all control and programming functions for the system.
- E. Signaling Line Circuits (SLC)
1. Each SLC shall provide power and communication with up to 127 analog or addressable devices, with a maximum of 90 devices per circuit to allow for future devices. The basic system shall consist of two (2) SLC (254 devices total) with expansion to four (4) SLC (508 devices total). Each SLC shall be capable of meeting the wiring requirements of NFPA 72, Style 4, 6 and 7.
 2. Each SLC shall communicate using a completely digital communication method to provide a more reliable, noise immune communication system. All communication between an addressable device and sensor shall use a validation method, such as providing a checksum for each message, to validate the integrity of each message. Systems which use a hybrid analog and digital communication scheme will not meet the requirements of this section.
 3. Each SLC shall use an Interrupt driven communication scheme to rapidly identify alarm conditions of any connected device. The normal polling scheme of the system shall be interrupted by a device in alarm. Identification of the alarming device shall be annunciated at the control system display within 2 seconds of activation.
 4. Control devices shall maintain local operating parameters and not require individual commands from the control system to activate.
 5. The system shall meet the requirements of NFPA 72 as a calibrated smoke sensitivity fixture.
- E. Enclosures
1. The system shall be housed in a small footprint enclosure with dimensions not to exceed 22" X 14.75" X 4.5".
 2. The enclosure shall be capable of surface or semiflush mounting without requiring additional hardware.
 3. The enclosure shall be painted either red or gray with a corrosion protective, harden finish.
- F. Power Supplies
1. The power supply shall operate upon either 120 VAC or 240 VAC, 50/60 Hertz and shall provide all power necessary to operate the control system.
 2. The power supply shall provide 5.0 amps of power for use on notification appliance circuits or auxiliary power circuits.
 3. Capability to supply an additional 5.0 amps of power shall be provided, bringing total output power capacity to 10.0 amps at 24 VDC.
 4. Each power supply shall provide battery charger capacity to sufficiently recharge a depleted set of 17AH batteries within 48 hours.
 5. Auxiliary power output circuits shall be provided for four wire detectors or addressable control modules. A separate circuit shall be provided to allow resetting the auxiliary power during a system reset. All auxiliary power circuits shall be power limited.

G. Field Programming

1. The system shall be programmable from the control panel without requiring use of personal computer.
2. All programming shall be accomplished via the standard 25 key-pad.
3. Two levels of password access shall be provided to prevent unauthorized modifications to the system operating configuration. Within each access level, up to 16 unique users can be assigned. The history buffer will record the user for each action taken requiring a password.
4. A Learn Mode shall be provided to identify changes in the installed system with the system configuration. Identified changes will then be presented to the user for validation. The Learn Mode shall also provide a means to program groups of devices with the same operating characteristics to minimize configuration times and errors.

H. Configuration Software

I. Configurable System Operations

2.04 SYSTEM COMPONENTS

A. Analog Photo Sensors

1. Each sensor shall store the sensor address and operating characteristics in nonvolatile memory at the sensor. The sensor shall use a threshold received from the control unit to determine when an alarm condition exists.
2. Each sensor shall have two alarm LEDs for 360° viewing. The alarm LEDs shall flash when communicating with the control panel. The alarm LEDs will illuminate steady during alarm conditions.
3. Sensitivity settings for photoelectric sensors shall be set and displayed on the LCD in % obscuration per foot.
4. Each sensor shall be capable of compensating for dust and dirt accumulation within the sensing chamber.
5. A calibrated light source shall be used to calibrate the fire level of the photoelectric sensor. Sensors that use a fixed fire level limit are not acceptable.

B. Analog Ionization Sensors

1. Each sensor shall store the sensor address and operating characteristics in nonvolatile memory at the sensor. The sensor shall use a threshold received from the control unit to determine when an alarm condition exists.
2. Each sensor shall have two alarm LEDs for 360 viewing. The alarm LEDs shall flash when communicating with the control panel. The alarm LEDs will illuminate steady during alarm conditions.
3. Each sensor shall be capable of compensating for dust and dirt accumulation within the sensing chamber.

C. Analog Thermal Sensors

1. Each sensor shall store the sensor address and operating characteristics in nonvolatile memory at the sensor. The sensor shall use a threshold received from the control unit to determine when an alarm condition exists.
2. Each sensor shall have two alarms LEDs for 360 Degree viewing. The alarm LEDs shall flash when communicating with the control panel. The alarm LEDs will illuminate steady during alarm conditions.

3. Sensitivity settings for thermal sensors shall be set and displayed on the LCD in degrees Fahrenheit. The set point for the thermal sensor shall be adjustable between 100 Degrees F and 156 Degrees F. The thermal detector shall operate on a fixed Temperature principal.

D. Fast Response Contact Module

1. Contact modules shall provide monitoring of dry contacts as initiating devices.
2. Each module shall store the sensor address and operating characteristics in nonvolatile memory at the module.
3. The module shall be mounted to a standard junction box and provide visual indication of status via a status LED. Optional mounting shall be available to allowing mounting the module in a junction box with a monitored contact.

E. Supervised Output Module

1. Each supervised output module shall be rated to operate listed notification appliances.
2. Circuit shall be rated for 2.0 amps @ 24 VDC.
3. Each module shall store the sensor address and operating characteristics in nonvolatile memory at the module.
4. Each module shall be individually selectable for silencing and walk test. A module programmed to operate during walk test will initiate the programmed pattern for 4 seconds when the appropriate initiating conditions are satisfied.
5. Each module shall operate under up to 16 different conditions occurring in the system. These conditions include combining various zones and zone states.

F. Solenoid Releasing Module

1. Circuit shall be rated for 2.0 amps @ 24 VDC.
2. Each module shall store the sensor address and operating characteristics in nonvolatile memory at the module.
3. The module shall be capable of actuating a listed solenoid or an Agent Release Circuit.
4. The module shall be protected from false actuation by an intelligent transistor.

G. Dual Relay Module

1. The module shall provide two independently operating and configurable relays.
2. Each relay shall be rated for 2.0 amps @ 24 VDC.
3. Each module shall store the sensor address and operating characteristics in nonvolatile memory at the module.
4. Each module shall operate under up to 16 different conditions occurring in the system. These conditions include combining various zones and zone states.
5. The module shall operate both relays without requiring a separate power source.

2.06 NOTIFICATION APPLIANCES

- A. Alarm Devices: Alarm devices shall be provided to annunciate alarm, pre-discharge, and discharge conditions for both the FM-200 and Pre-Action sprinkler systems.
- B. FM-200 Alarm/Pre-Discharge Signals: Alarm/pre-discharge mode audible indication shall be provided by a vibrating horn rated at 24 VDC with an output of 90-94 dBA. The vibrating horn shall be polarized for supervisory purposes and consume only 0.035 amperes at 24 VDC. Field wiring connections shall be made to terminal strips located on the device. The horn shall be ruggedly constructed and have a red baked enamel finish. The horn shall function with the following sequence:

ALARM: Slow Cadence

PRE-DISCHARGE: Fast Cadence

- C. Discharge Steady: A strobe light shall provide discharge mode indication. The strobe light shall operate on 24 VDC. The strobe light shall develop a peak intensity of over 8000 candle power within ten (10) microseconds and light output shall decay within one hundred (100) microseconds. The strobe lens shall be of white translucent acrylic with the work @FM-200@ imprinted upon it.

2.06 GRAPHIC ANNUNCIATOR PANEL:

- A. A custom Graphic Display Panel shall be furnished by the detection/control equipment manufacturer. The Graphic Display Panel will display all detection devices and indicate their overall current status. Communications between the system control panel and the graphic display panels shall be via a fiber optic link. This link will provide all data needed by the Graphic Display Panels to display both alarm and trouble status for each addressable device. The configuration of the Graphic Display Panels shall be accomplished through IBM-PC compatible configuration software. No hard wired connections between the Graphic Display Panels and the system control panel shall be allowed. The exact quantity and type of Graphic Display Panels will be as indicated on the drawings.
- B. Individually colored LED's shall be provided, as needed, for each device represented on a Graphic Display Panel. The LED's will represent all detection devices for the three (3) zones.
- C. A 110 volt A.C. power source shall be provided by others at each Graphic Display Panel location.
- D. The graphic panel shall be equipped with audible alarm, silence switch, lamp test switch, and the capability to recreate the alarm sequence by response of the detection device.
- E. Wiring for the detection system, the extinguishing system, and damper trip or releases shall be run in accordance with the one-line diagram schematic diagrams provided by the specification. Wiring must be conduit. Use 14 AWG MINIMUM, 600 volt, 105 C, UL listed wire. Make wire runs continuous unless unusually long runs make splices unavoidable. Splices must be soldered; wire nuts are not acceptable. NOTE: The 115 volt 60 Hz single phase power input line must be in separate conduit and connected to the main building line through a separate 15 amp circuit dedicated to the extinguishing system.

PART III - EXECUTION

3.01 INSTALLATION

- A. All work shall be installed as shown and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified.
- B. Power Supply for the System: A single dedicated branch-circuit connection for supplying power to each building system shall be provided. Emergency power supply shall be automatically transferred upon failure of the normal power supply.
- C. Wiring: Wiring for systems shall be installed in 3/4-inch minimum diameter conduit; however, the wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting, power or other sub-systems. No more than one conductor shall be installed under any screw terminal. All circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to terminals with each terminal marked in accordance with the wiring diagram for identification. Connections shall be made with either crimp-on terminal spade lugs or with approved pressure type terminal blocks. All wiring within any control equipment shall be readily accessible without removing any component parts. The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.

- D. Control Panel: The Control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 12 inches above the finished floor or more than 78 inches above the finished floor. All manually operable controls shall be at least 3 feet and less than 5 feet above the finished floor. Panel shall be installed to comply with the requirements of UL 864.
- E. Detectors: Detectors shall be installed in accordance with NFPA 72E. Detectors shall be at least 12 inches from any part of any lighting fixture. Detectors shall be located at least 3 feet from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in free space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 3 feet, sway bracing shall be provided. In general, detector coverage shall not exceed 125 square foot per detector.
- F. Signaling Devices: Signaling devices shall be mounted a minimum of 8 feet above the finished floor unless limited by ceiling height or otherwise indicated.
- G. Annunciator Equipment: Annunciator equipment shall be mounted and provided where indicated.

3.02 TESTING

- A. The Contractor shall notify the Architect/Engineer 30 days before the performance and acceptance tests are to be conducted. The tests shall be performed in the presence of the Architect/Engineer and Owner under the supervision of the fire alarm system manufacturer's qualified representative. The Contractor shall furnish all instruments and personnel required for the tests.
- B. Preliminary Tests: Upon completion of the installation, the system shall be subjected to functional and operational performance tests, including tests of each installed smoke detector. Tests shall include the meggering of all system conductors to determine that the system is free from grounded or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment. Smoke detector bases shall be equipped with jumpers for the megger test. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional.
- C. Acceptance Test: The testing shall be in accordance with NFPA 72H and shall verify that all previous deficiencies have been corrected. The test shall include the following:
 - 1. Test of each function of the control panel.
 - 2. Test of each circuit in both trouble and normal modes.
 - 3. Tests of alarm initiating devices in both normal and trouble conditions.
 - 4. Tests of each control circuit and device.
 - 5. Tests of each alarm indicating device.
 - 6. Tests of the battery charger and batteries.
 - 7. Complete operational tests under emergency power supply.
 - 8. Visual inspection of all wiring.
 - 9. Opening the circuit at each alarm initiating and indicating device to test the wiring supervisory feature.
- D. Coordinate testing with requirement of Section 15340.

END OF SECTION 16718

PART I - GENERAL1.01 OVERVIEW

- A. This document contains the specification and input/output summaries for a Building Monitoring System (BMS). The system architecture shall utilize intelligent distributed control modules, located at each site, which communicate over an EIA-485 controller network. Operator Workstations may be connected to the controller network via direct EIA-232, modem, or Ethernet Local Area Network (LAN) connections through a microprocessor based communication device. The Operator Workstations shall be Windows XP compatible computers with color monitors and associated printers as specified herein, and are located at this facility. Primary interface to system shall be through Internet Explorer Browser from any workstation on the system network. Unlimited number of users shall be available. The system shall provide the Building Monitoring for the air conditioning, Data support systems and electrical distribution systems and shall interface with other microprocessor based building subsystems as specified.

1.02 INSTRUCTIONS TO BIDDERS

- A. The system specified herein is based upon Automated Logic Corporation. However, a system equal to this system shall be acceptable.

1.03 SCOPE OF WORK

A. Contractor's Responsibilities

The Contractor shall furnish and install a complete system with all necessary hardware, wiring, computing equipment and software as defined in this specification. Any variances from this specification or related documentation shall be submitted in writing at the time of bid.

B. System Requirements

1. All material and equipment used shall be standard components, regularly manufactured and available and not custom designed especially for this project. All systems and components, except site specific software, shall have previously been thoroughly tested and proven in actual use prior to installation on this project.
2. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
3. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

C. Equipment

1. System Hardware - The Contractor shall provide the following:
 - a. Operator workstation(s) and control modules.
 - b. All sensing devices and necessary transducers to perform the functions listed in I/O Summary Tables.
 - c. All relays, switches, indicating devices, and transducers required to perform the functions listed in I/O Summary Tables.
 - d. All monitoring and control wiring and air tubing.
 - e. All modems and accessories.
2. System Software - The Contractor shall provide all software identified in Part III of this specification. The database required for implementation of this specification shall be provided by the Contractor, including: point descriptor, alarm limits, calibration variables, graphics, reports and point summaries.

D. Input/Output Summary Table

1. The system as specified shall monitor, control, and calculate all of the points and perform all the functions as listed in electrical drawing.

E. Codes and Regulations

1. All electrical equipment and material and its installation shall conform to the current requirements of the following authorities:
 - a. Occupational Safety and Health Act (OSHA)
 - b. National Electric Code (NEC)
 - c. National Fire Code
 - d. Uniform Mechanical Code
 - e. Uniform Building Code
 - f. Uniform Plumbing Code
2. All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:
 - a. UL916 for Open Energy Management
 - b. FCC Part 15, Sub-Part B, Class A
 - c. CE Electro Magnetic Compatibility
3. The control system manufacturer shall be ISO9001 listed for design and manufacture of environmental control systems for precise control and comfort, indoor air quality, HVAC plant operation, energy savings and preventative maintenance.
4. Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

1.04 GENERAL CONDITIONS

A. Correction of Work

1. The Contractor shall promptly correct all work found defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.
2. If, within the warranty period required by the Contract Documents, any of the work is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of a written notice to do so.

B. Coordination During Construction

1. The Contractor shall coordinate any necessary changes in work and shall provide scheduling to minimize any disruption.
2. The Contractor shall protect the installed works by other trades.
3. The Contractor shall coordinate with other trades.
4. The Contractor shall repair any damage caused by his work to building(s) and equipment at no additional cost to the owner.

C. Warranty

The Contractor shall warrant that all systems, subsystems, component parts, and software are fully free from defective design, materials, and workmanship for a period of one year from the date of final acceptance.

1.05 SUBMITTALS, DOCUMENTATION AND ACCEPTANCE

A. Submittals

1. Shop Drawings. A minimum of 6 copies of shop drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical

literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

2. Shop drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for complete review so that all installations can be completed per the project's completion schedule. Ten working days shall be allowed for review submittal.
3. All drawings shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation. All shop drawings will be acknowledged in writing by the architect before installation is started and again after the final checkout of the system. The system will not be considered complete until the 'as-built' drawings have received their final approval. The Contractor shall deliver 4 sets of 'as-built' drawings.
4. Before final configuration, the Contractor shall provide I/O Summary forms to the engineer that include:
 - a. Description of all points.
 - b. Listing of binary and analog hardware required to interface to the equipment for each function.
 - c. Listing of all application programs associated with each piece of equipment.
 - d. Failure modes for control functions to be performed in case of failure.
5. The Contractor shall provide an accurate graphic flow diagram for each software program proposed to be used on the project as part of the submittal process. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-built" graphic software flow diagrams required by this specification.

B. Operating and Maintenance Manuals

Operating and Maintenance (O&M) manuals for the system shall include the following categories: Workstation User's Manual and Project Engineering Handbook, and Software Documentation. Project specific manuals shall include detailed information describing the specific installation.

1. Workstation User's Manual shall contain as a minimum:
 - a. System overview
 - b. Networking concepts
 - c. Activating the workstation
 - d. Using the mouse and login
 - e. Workstation screen menus and their definitions
 - f. Establishing setpoints and schedules
 - g. Uploading and downloading software, setpoints, schedules, operating parameters and status between the operator workstation and field hardware.
 - h. Collecting trend data and generating trend plots
 - i. Enabling alarms and messages
 - j. Report generation
 - k. Backing up software and data files
 - l. Using the operator workstation with 'third party' software
2. Project Engineering Manual shall contain as a minimum:
 - a. System architecture overview
 - b. Hardware cut-sheets and product descriptions
 - c. Wiring diagrams for all controllers and field hardware
 - d. Installation, mounting and connection details for all field hardware and accessories
 - e. Commissioning, setup and backup procedures for all field hardware and accessories
 - f. Commissioning, setup and backup procedures for workstation software.
 - g. Commissioning, setup and backup procedures for workstation software.
3. Software Documentation shall contain as a minimum:
 - a. Graphical representation of all control algorithms for every piece of mechanical equipment controlled on the project, together with a glossary or icon symbol library detailing the

function of each graphical icon. 'Line by line' computer program documentation is unacceptable.

- b. Detailed description of control sequences used to achieve the specified sequences.
- c. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BMS. i.e. a VAV terminal box may be the source for increased cooling demand and require the primary VAV AHU to operate which requires the chillers to operate.
- d. Detailed listing of all specified alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.

C. Acceptance Test and Acceptance

1. Upon completion of the installation, the Contractor shall start up the system and perform all necessary calibration, testing, and debugging operations. An acceptance test shall be performed by the Contractor in the presence of the Owner's representative.
2. When the system performance is deemed satisfactory, the system parts will be accepted for beneficial use and placed under warranty. At this time, a "notice of completion" shall be issued by the engineer and the warranty period shall start.

D. Owner's Instructions

1. The Contractor shall provide full instructions to designated personnel in the operation, maintenance, and programming of the system. The training shall be specifically oriented to the system and interfacing equipment installed.

PART II – PRODUCTS HARDWARE

2.01 BMS SERVER AND WEB BROWSER GRAPHICAL USER INTERFACE (GUI)

- A. System Overview: The BMS contractor shall provide system software based on server/thin-client architecture, designed around the open web technology standards. The BMS server shall communicate using ASHRAE's BACnet/IP protocol.
- B. Thin-Client/Workstation Software: The intent of the thin-client architecture is to provide the operator(s) complete access to the BMS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (6.0 or later versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the workstation used to access the BMS via a web browser. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:
 - A. Trending
 - B. Scheduling
 - C. Downloading Memory to field devices
 - D. Real time 'live' Graphic Programs
 - E. Tree Navigation
 - F. Alarm / Event information
 - G. Configuration of operators
 8. Execution of global commands
- C. Thin-Client/Workstation Hardware: Provide (2) workstations to be used as thin-clients. The Web Browser GUI shall be Microsoft Internet Explorer (6.0 or later) running on Microsoft XP. No special software shall be required to be installed on the workstations to access the BMS via a web browser. The following is the minimum hardware requirements for the workstations:

1. 2.0 GHz or higher CPU
 2. 512MB SDRAM
 3. 40 gigabyte hard disk, SVGA Card with 1024x768, 24-bit True Color, 48X CD-RW Rom Drive, 17" SVGA Color Monitor
 4. 10/100 Network Interface Card (NIC)
 5. Microsoft Windows XP professional
 6. Internet Explorer 6.0 or later
- D. Central Server BMS Software: The BMS server software must support at least the following server platforms (Windows NT, Sun Solaris and Linux). The BMS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BMS software is not acceptable. The server software must include at least (4) simultaneous user access. The BMS server software shall utilize a Java DataBase Connectivity (JDBC) compatible database. Provide the following functionality as a minimum:
1. Input/output capability from the thin-client/workstations.
 2. Operator system access levels via BMS software password.
 3. Zone level scheduling
 4. Database creation and support.
 5. Dynamic color graphic displays of the following as a minimum: building elevation, building floor plans, equipment schematics with data points.
 6. Alarm processing.
 7. Event processing.
 8. Automatic restart of field equipment on restoration of power.
 9. Data collection.
 10. Graphic development on workstation.
 11. Maintenance management.
- E. High Availability Central Server Hardware: The BMS contractor shall supply a server cabinet to house the BMS Central Server and supply a local area network (LAN) to support the BMS Central Server, workstations and any other BMS network capable hardware. All BMS LAN hardware requiring an IP address shall use an addressing scheme consistent with the 192.168.168.0 network. The BMS contractor shall configure the BMS central server dual RJ45 10/100/1000BaseT Ethernet ports for "Smart Load Balance and Fail Over". These dual ports on the BMS server shall be used for connecting the BMS system to the Owner's LAN. These dual connections shall use IP addresses supplied by the owner. Provide a server configuration that includes the following components as a minimum:
1. Single Intel 2.4 GHz Xeon Processor, 400 MHz front side bus with capability of supporting a second 2.4 GHz processor.
 2. 512 KB L2 Advanced Transfer Cache.
 3. Chipset must support 5 PCI buses.
 4. 1GB 200MHz DDR SDRAM
 5. 3 full length PCI-X expansion slots.
 6. Dual-channel integrated Ultra3 SCSI Adaptec AIC-7899 (160 Mb/s) controller
 7. Embedded Expandable RAID controller, Version 3, Dual-Channel Integrated with battery-backed cache.
 8. 5 X 1" hot-plug SCSI drive bays.
 9. Four 73GB (10,000 rpm) Ultra3 SCSI hard drives configured as RAID 5.
 10. Dual Embedded Gigabit Server Adapter Network Interface Card.
 11. 10/100 Dual Port Server Adapter Network Interface Card.
 12. Hot plug, redundant 500 watt power supplies (Voltage 100-240 VAC).
 13. Rack-Mountable Chassis with max 2U rack height.
 14. Front mounted LCD alphanumeric display for error messages and system status.

15. Built-in Automatic Server Recovery shall reboot and restart the server if the OS hangs without user intervention.
- F. High Availability Central Server Database Software: The BMS contractor shall use Microsoft SQL 2000 or equivalent commercially available enterprise system for hosting its database. The database size shall only be limited by the size of the RAID 5 volume. The Relational Database Management System (RDMS) shall be configured to perform a complete database backup on a daily basis. These backups shall be kept on the server for a total of 5 weeks. Starting week six, the current backup shall replace the oldest backup. The net effect is to have thirty-five consecutive backups on the server, one complete backup for each day of the week for five weeks. This backup shall be fully automated with no user intervention required. The backup routine shall run without requiring shutting down or in any way limiting the availability of the BMS system and shall be transparent to the end user of the BMS. In addition, the RDMS shall be configured to perform a complete database backup on a monthly basis. These backups shall be kept on the server for a total of 12 months. Starting month thirteen, the current backup will replace the oldest backup. The net effect is to have twelve consecutive backups on the server, one complete backup for each month of the year. This backup shall be fully automated with no user intervention required. The backup routine shall run without requiring shutting down or in any way limiting the availability of the BMS and shall be transparent to the end user of the BMS.
- G. Software Components: All software components of the BMS system software shall be installed and completed in accordance with the specification. BMS system components shall include:
1. Server Software, Database and Web Browser Graphical User Interface
 2. System Configuration Utilities for future modifications to the system
 3. Graphical Programming Tools
 4. Direct Digital Control software
 5. Application Software
- H. Communication Protocols and Encryption: The native protocol for the BMS server software shall be BACnet over Ethernet DataLink as defined by ASHRAE standard SPC135. The BMS Server shall support BACnet/IP Annex J to enable communication through common routers. Proprietary protocols over TCP/IP are NOT acceptable. Communication between the Web Browser GUI and BMS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).
- I. Dynamic Graphic One Line Display: System shall display a Dynamic One Line Power Graphic that accurately depicts the present voltage/current flow of the electrical distribution system. Active breakers or buss bars shall be shown using the color RED to indicate path of current. Inactive Breakers or buss bars shall be shown using the color GREEN to indicate open or inactive equipment. Colors shall dynamically change when equipment becomes active or inactive to accurately depict the electrical distribution. Equipment shall include, but not be limited to, Utility feeds, Low Voltage Distribution Breaker Boards, Generators, Paralleling Gear, UPS Breaker Boards, Load Banks, UPS, SCC, PDU, TVSS, RPP's. Display shall encompass the entire one line diagram from Utility Feed to Floor Distribution, including all mechanical equipment. One line shall have active pickables that take the operator to the individual piece of equipment when chosen via the mouse.

2.02 BUILDING SYSTEMS INTEGRATION

A. Bi-directional Protocol Translator

The Building Automation System (BMS) shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems as well as other manufacturers control systems as specified below. These systems shall be controlled, monitored and graphically programmed through the Graphical User Interface (GUI) software of the BMS.

1. All system information specified in the I/O summary and related documents shall be available to the BMS. Read and write capability, as indicated, shall be provided to the mechanical and electrical equipment indicated and be available to the BMS system. No limits shall be placed by the manufacturer on the owner or BMS with regard to the access, transmission or modification of data provided from the equipment control system.
 2. Full cooperation by the Original Equipment Manufacturer in this open protocol effort shall be a requirement for bidding this project. No exceptions shall be allowed and no bid shall be accepted which does not precisely define how the proposed equipment will comply with this section. OEM manufacturers shall bid BACnet™ facilitating interoperability between OEM electrical/mechanical sub-systems and the BMS.
- B. If the equipment manufacturer does not have this capability, they shall contact the authorized representative of the BMS for assistance and shall include in their equipment price any necessary equipment obtained from the BMS manufacturer to comply with this section.
- C. Other equipment manufacturers shall provide this seamless integration through the use of a BACnet microprocessor based, bi-directional protocol translator (BPT) as specified below.
1. The BPT shall be a microprocessor based communication device designed to provide seamless, two-way translation between two or more standard or non-standard protocols.
 2. The BPT communicate between native BACnet controllers residing on the controller network. This network shall be EIA-485 running at 156 kbps using ARCNET. The other communication port shall have the ability to be configured for different protocols. One of these shall consist of a terminal board connector which is jumper selectable for EIA-232, 2-wire EIA-485, or 4-wire EIA-485. The other port shall consist of an EIA-232, 9-pin connector. Both ports shall be software selectable for up to 38.4Kbps.
 3. The BPT shall provide full custom programmability of the data flowing between the networks using the same graphical programming as specified herein. The system shall have the ability to create custom building control strategies using global data between networks.

2.03 LOCAL AREA NETWORK BRIDGES AND ROUTER

Local Area Network bridges and routers must be of a modular design to ensure reliability and system performance.

A. Local Area Network Gateway (LAN Gateway)

1. The LAN Gateway shall be a microprocessor based communications device, which functions as a communications gateway between a controller network and a Local Area Network (LAN). It shall communicate with controllers utilizing ARCNET over EIA-485 network at 156 Kbps and shall be capable of acting as a bridge and router between designated BACnet data links and the ARCNET data link. It shall offer PTP to ARCNET and BACnet/IP to ARCNET routing capability. Controller networks that utilize proprietary protocols at the controller network level are unacceptable.
2. Each LAN Gateway shall support a controller network on which may reside up to 100 controllers.
3. The controller network shall use BACnet as its native communication protocol. The communication between controllers shall be at least 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.
4. The LAN, which interconnects LAN Gateways may be configured as EIA-485 (38.4 kbps), Ethernet (10/100bT), or FDDI (100Mbps), all of which may be implemented over fiber optic, twisted pair, or coaxial cable. In the case of Ethernet connections, the LAN Gateway may be configured as Ethernet 10Base-T (10/100bT), which may be implemented over unshielded twisted pair.
5. The LAN Gateway shall provide two EIA-232 ports, which can be connected to Operator Workstations, portable computers, or modems.

6. LAN Gateway shall provide full arbitration between multiple users, whether they are communicating through the same or different LAN Gateways.
7. The LAN Gateway shall be responsible for routing global information from the various controller networks, which may be installed throughout a building.
8. A total of 255 (two hundred and fifty five) LAN Gateways shall be supported on each LAN, each LAN Gateway supporting a minimum of 100 controllers (one hundred).
9. The LAN Gateway shall be capable of utilizing FLASH memory, which allows firmware updates to be performed remotely.

B. Controller Network Gateway (CN Gateway)

1. The CN Gateway shall be a microprocessor-based communication device that provides communication between the operator workstation and/or modem with the controller network.
2. The CN Gateway shall communicate with the operator workstation using an EIA-232 serial communication port and with control modules utilizing ARCNET over EIA-485 network at 156 Kbps. The CN Gateway shall be capable of acting as a bridge and router between designated BACnet data links and the ARCNET data link. It shall offer PTP to ARCNET routing capability.
3. Controller networks that utilize proprietary communication protocols or non-industry standard protocols shall be unacceptable.
4. A second EIA-232 port shall allow the CN Gateway to communicate with another operator workstation or a portable field computer either through a modem or through a direct EIA-232 connection.
5. Each EIA-232 port shall be switch selectable for communication speeds up to 38.4 Kbps.
6. Each CN Gateway shall support a controller network on which may reside a minimum of 100 control modules in any combination.
7. The controller network shall use BACnet as its native communication protocol. The communication between controllers shall be ARCNET at 156 kbps implemented over an unshielded twisted pair at the Data Link Layer.
8. The CN Gateway shall utilize FLASH memory, which shall allow for firmware updates to be performed remotely.

2.04 STANDALONE CONTROLLERS

A. General Purpose/Multiple Application Controllers

1. General Purpose/Multiple Application controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):

Objects • Binary Input • Binary Output • Binary Value • Analog Input • Analog Output • Analog Value • Calendar • Schedules	Services • Read Property • Write Property • I-Am • I-Have • Read Multiple Property • Write Multiple Property • Who-Has • Who-Is
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2. Each General Purpose/Multiple Application Controller must be capable of standalone direct digital operation utilizing its own 32 bit processor, non-volatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. All non-volatile flash memory shall have a battery backup of at least five years. Firmware revisions to the module should be able to be made from the local workstation, portable operator terminals or from remote locations over modems or LANs.
3. The General Purpose/Multiple Application Controllers shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. These expander modules shall expand the total point capacity

of each controller up to 192 points where specified. The controller, in conjunction with the expansion modules, shall act as one standalone controller.

4. All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation.
5. Each General Purpose/Multiple Application Controller shall execute application programs, calculations, and commands via a 32 bit microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the operator workstation.
6. Each General Purpose/Multiple Application Controller shall reside on a BACnet communications bus and utilize native BACnet communications between all other controllers and devices on the network. Each controller shall include self-test diagnostics, which allow the controller to automatically relay to the network controller any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.
7. Each General Purpose/Multiple Application Controller shall contain both software and firmware to perform full DDC PID control loops.
8. Each General Purpose/Multiple Application Controller shall contain a serial port for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.
9. Input-Output Processing:
 - a. Digital outputs shall be relays, 24VAC or VDC maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and either dry contact or bussed. Triac outputs are unacceptable. Each output shall have a manual Hand-Off-Auto switch to allow for override and an LED to indicate the operating mode of the output.
 - b. Universal inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC, 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power 250 Ohm input impedance, dry contact - 0.5mA maximum current.
 - c. Analog output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.
 - d. Analog pneumatic outputs shall be 0-20psi. Each pneumatic output shall have a feedback transducer to be used in the system for any software programming needs. The feedback transducer shall measure the actual psi output value and not a calculated value. Each output shall have a manual override switch, which will allow each output to be configured in one of three ways: open, closed, or automatic operation. An LED shall indicate the state of each output.

B. General Purpose/Single Application Controllers

1. The General Purpose/Single Application Controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, following Objects and Application Services (Conformance Class 3):

Objects	• Binary Input • Binary Output • Binary Value • Analog Input • Analog Output • Analog Value • Calendar • Schedules	Services	• Read Property • Write Property • I-Am • I-Have • Read Multiple Property • Write Multiple Property • Who-Has • Who-Is
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2. The General Purpose/Single Application controllers must be capable of stand-alone DDC operation utilizing its own 32 bit processor, nonvolatile flash memory, input/output, 10 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. All nonvolatile Flash memory shall have a battery backup of at least five years. Firmware revisions to the module should be able to be made from the local workstation, portable operator terminals or from remote locations over modems or LANs.

3. All point data, algorithms, and application software within the controllers shall be custom programmable from the Operator Workstation.
4. Each General Purpose/Single Application Controller shall execute application programs, calculations, and commands via a 32 bit microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.
5. Each General Purpose/Single Application Controller shall reside on a BACnet communications bus and utilize native BACnet communications to/from other controllers and devices on the network. Each Controller shall include self-test diagnostics, which allow the controller to automatically relay to the network controller any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.
6. Each General Purpose/Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.
7. A serial port shall be provided for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.
8. The General Purpose/Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20°F to +150°F (-28.9° to 65.6°C).
9. Input-Output Processing:
 - a. Digital outputs shall be relays, 24VAC or VDC maximum, 3 amp maximum current. Triac outputs are unacceptable. Each output shall have a manual Hand-Off-Auto switch to allow for override and an LED to indicate the operating mode of the output.
 - b. Universal inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC - 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.
 - c. Analog electronic outputs shall be voltage mode 0-10VDC or current mode 4-20mA.
 - d. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.

2.05 LOCAL OPERATOR KEYPAD DISPLAY

- A. Local Keypad Display (LOK) keypad and display shall be provided where indicated in the I/O summary. The LOK shall plug directly in to any general purpose/multi application controller and enable maintenance personnel to access and modify specified building control parameters in any DDC control panel. The LOK shall be panel mounted [or wall mounted].

The LOK shall comprise a minimum of four function keys and employ a backlit display for easy reading in poor lighting conditions. Each function key shall act as a 'hot-key' to specified menu's comprised of control parameters. The display shall utilize English language descriptors rather than cryptic code and a menu penetration technique to access data. Clearly marked 'up' and 'down' arrow keys shall be used to move between point descriptors listed in each menu. The LOK backlit display shall be 4 by 40 characters or 2 by 16 characters, as specified by location in the I/O Point Summary.

Additionally, the large LOK shall be equipped with a numeric keypad to simplify modification of parameter values. The LOK shall also be used as a Portable Operator Terminal. It shall not be necessary to use central workstation software to enable operation of the LOK, nor shall it be necessary to remove in situ communication cabling or connectors from the controller to connect a LOK. A dedicated socket shall be provided on each general purpose/multi-application controller to facilitate connection of the LOK.

The English language menus in the LOK shall be constructed using industry standard HTML. Access to building control parameters shall be protected by password entry.

2.06 FIELD HARDWARE/INSTRUMENTATION

- A. Input Devices

1. Temperature sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use.
2. Sensors used for mixed air application shall be the averaging type and have an accuracy of +1°F (0.5°C).
3. Outside air temperature sensors shall have a minimum range of -52°F to 152°F (-46.6°C to 66.6°C) and an accuracy of within +1°F (0.5°C) in this temperature range.
4. Room temperature sensors shall have an accuracy, of +0.36°F (0.25°C) in the range of 32°F to 96°F (0°C to 35.5°C).
5. Chilled water and condenser water sensors shall have an accuracy of +0.25°F (0.15°C) in their range of application.
6. Hot water temperature sensors shall have an accuracy of +0.75°F (0.3°C) over the range of their application.

B. Pressure Instruments

1. Differential Pressure and Pressure Sensors.
2. Pressure Switches.
3. Flow Switches.
4. Watt-hour Transducers.
5. Voltage-to-Digital Alarm Relays.
6. Humidity Sensors.
7. Current Sensing Relays.

C. Output Devices

1. Control Relays.
2. Solid State Relays (SSR).
3. Electric Solenoid Operated Pneumatic (EP) Valves.
4. Electric to Pneumatic (EP) Transducers.

Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.

Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.

D. Field Testing and Programming Equipment

A portable laptop or notebook computer shall interface via standard push-in connection at an asynchronous serial port located at the Control modules and at selected enhanced zone temperature sensors as indicated on project plans. This portable unit shall be capable of full global communications with all Control modules connected within the respective network and shall provide functionally identical user interface to the Workstation, in non-graphic format. Units shall be able to interrogate all points and alter all programming.

PART III - PRODUCTS SOFTWARE

3.01 SYSTEM SOFTWARE OVERVIEW

- A. The BMS Contractor shall provide all workstation software required for efficient operation of the BMS system specified herein. Software shall be modular in design to provide maximum flexibility,

expansion and future revision of the system. All functionality described herein shall be regarded as a minimum.

The system software shall include the following as a minimum:

1. Complete database entry
2. Configuration of all controller and operator application programs to provide the sequence of operation indicated.
3. Graphics of each system as shown on the I/O Summary Tables
4. Configuration of all reports and point summaries indicated
5. Event/alarms comprised of Urgent Alarms, Alarms, and Messages as specified.

B. The software shall be comprised of the following elements:

1. System executive software
2. Software for user control over system configuration at the CS location
3. Facility monitoring functions
4. Direct digital control
5. Application software

3.02 GRAPHICAL USER INTERFACE WORKSTATION SOFTWARE

A. Thin-Client/Workstation Software: The intent of the thin-client architecture is to provide the operator(s) complete access to the BMS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (6.0 or later versions), and Windows as well as non-Windows operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the workstation used to access the BMS via a web browser. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

1. Trending
2. Scheduling
3. Downloading Memory to field devices
4. Real time 'live' Graphic Programs
5. Tree Navigation
6. Parameter change of properties
7. Setpoint Adjustments
8. Alarm/Event information
9. Configuration of operators
10. Execution of global commands

B. The Graphical User Interface (GUI) workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color using industry standard Internet Explorer Browser 5.5 or higher.

C. The control network shall be organized in to a logical hierarchy of systems, sites, areas, and equipment. In this logical organization, 'equipment' shall refer to actual mechanical, electrical, or other devices such as air handling units, chillers, lighting control panels, and other hardware specified in the I/O Summary. Equipment may be subdivided into smaller pieces of equipment. 'Area' shall refer to the physical area within a building such as individual floors or other geographical boundary. 'Site' shall refer to a collection of equipment controlled by a single, standalone network of control modules. Generally, a 'site' shall coincide with a large 'area', such as an individual building or an individual floor within a large building. A 'system' shall refer to a collection of sites, areas, and equipment contained within a single database maintained by a single group of operators.

D. General area maps shall show locations of controlled buildings in relation to local landmarks.

- E. The building operator shall be able to communicate and direct all control functions through the use of a 2-button mouse operator interface to monitor and control all functions and sequences within the system. The following information shall be selectable from a button menu bar available on the various graphics:

Exit	Trends	Help Files
Setpoints	Transfer (Upload/Download)	Transfer Manager
Schedules	Module Status	Schedule Graphs
Parameters	Print	Groups
Minimize	Calibrate Points	Configure Points
Return to Last View	Manual Commands	Live Graphic Function Book

Programming, scheduling and setpoint changes shall be accessible for modification on each menu for the associated equipment. Operator shall be able to automatically transfer changes from the workstation to the appropriate field control module program for the equipment being controlled. Operator shall be able to transfer parameters, setpoint information and schedules from the field control modules to the workstation.

- F. The workstation software shall allow receipt of building data while the workstation software is minimized.
- G. Operators shall be able to control system functions based on their password level. The primary operator interface shall be via a two button mouse.
- H. All operator commands shall be in the graphics database and menu driven. After the operator selects the desired object item or menu, the system shall display either the status of selected object item or the allowable options available. System shall inform the operator of any errors performed in executing operator commands.
- I. The software shall utilize an industry standard database engine compatible with Microsoft Access. The system database shall comprise of a logical grouping of points, a building, multiple buildings or end-user sites as specified herein and in the I/O summary.
- J. The system shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. This color band shall normally correspond to the dead band between the onset of mechanical heating or cooling. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange.

Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red.

The system shall be capable of utilizing the mouse operator interface device to change individual zone temperature bar and by pressing a button, and by moving the mouse cursor to an increased or decreased temperature setpoint within that zone. The system shall also be capable of utilizing the mouse interface device or a conventional keyboard to change a numeric temperature setpoint value instead of utilizing the graphic temperature bar. The floor plan graphic shall then be able to change colors on a zone by zone basis to reflect the actual temperature in each zone relative to the changed desired heating or cooling setpoint. The system shall be capable of globally changing all setpoints.

- K. The intent of the GUI is to ensure the operator is always aware of his position within the system as well as how to logically progress through the graphical hierarchy to select any desired graphic or other source of information. The system software shall provide the operator with the capability of returning

to any previous graphic by clicking the previous button or by pointing to a graphic label then pushing a single button on the mouse operator interface.

The system software must be programmed to provide a separate color graphic for:

1. Each piece of equipment monitored or controlled including each terminal unit.
 2. Each building
 3. Each floor and zone controlled
 4. Each schedule
 5. Each trend
 6. Each Graphical Software Program
- L. Dynamic Graphic One Line Display: System shall display a Dynamic One Line Power Graphic that accurately depicts the present voltage/current flow of the electrical distribution system. Active breakers or buss bars shall be shown using the color RED to indicate path of current. Inactive Breakers or buss bars shall be shown using the color GREEN to indicate open or inactive equipment. Colors shall dynamically change when equipment becomes active or inactive to accurately depict the electrical distribution. Equipment shall include, but not be limited to, Utility feeds, High, Medium and Low Voltage Distribution Breaker Boards, Generators, Paralleling Gear, UPS Breaker Boards, Load Banks, UPS, SCC, PDU, TVSS, RPP's. Display shall encompass the entire one line diagram from Utility Feed to Floor Distribution, including all mechanical equipment. One line shall have active pickables that take the operator to the individual piece of equipment when chosen via the mouse.
- M. User access shall be restricted. Operator sign on shall require an assignable password. Each operator can be assigned to any one of a hundred levels of system access.
- N. Equipment operation schedules shall be definable for the entire system, area or individual equipment. For example, a user shall have the ability to define a single common occupancy schedule for every piece of equipment within a system or an area. Changes to the single schedule shall be made at this single point and shall automatically be passed to all equipment and individual controllers within the system without further user intervention. Exceptions to this single common schedule or additional occupancies shall be made at any area or equipment level. The schedule display for any piece of equipment shall clearly indicate every individual schedule, which affects equipment, as well as the net operating schedule which shall result from all contributing schedules.
- O. Users shall be able to define Schedule Groups, comprised of a user-defined group of equipment that may be scattered throughout the facility and site. For example, the user shall be able to define a single Group Schedule to control all desire rooms on either a normal (day-to-day) or exception ('special Saturday working') basis.
- P. The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the user schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
- Q. The system shall be able to trend and display either numerically or graphically any analog or digital physical point or calculated point or any output from any of the microblocks in the Graphics Programs.
- R. The system shall be able to simultaneously graphically display four trends per graph (limited only by the resolution of the viewing screen), each trend comprise of the most recent two hundred and eighty eight (288) samples. Sample intervals shall be as small as one (1) second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for display, which have different trend intervals, the system will automatically scale the axis.

- S. The system shall have the ability to view trends from anywhere within the same control module network simultaneously. Trends shall be picked from a hierarchical tree using the mouse in a similar manner to Windows File Manager.
- T. Trends shall be able to dynamically update at user-defined intervals.
- U. It shall be possible to zoom-in on a particular section of a trend for more detailed examination.
- V. It shall be possible to pick any point on a trend and have the numerical value displayed.
- W. Each module shall be capable of automatically uploading all accumulated trend data to the workstation for permanent storage on hard disk.
- X. Trend Historian (TH) - The system operator shall have the ability to set up a continuous trend of any point, as described above, for a user defined period of time.
- Y. Any point assigned to the TH will automatically upload to the workstation hard disk the trend information in groups of the most recent 288 (two hundred and eighty-eight) samples. This will continue as long as the point is assigned to the TH.
- Z. The operator will be able to simultaneously graphically display any 4 (four) values being trended by the TH. The operator will be able to move back in time by clicking with the mouse on a button marked 'back', or forward in time by clicking on a button marked "forward". The operator will also have the option of typing in a date in the approximate location, which will automatically display the trend information for that time period.
- AA. Run Time - The system shall provide run time information for all digital output and input points for all modules on command from the operator. Run time hours and start time date shall be retained in non-volatile module memory. Each control module shall be capable of automatically uploading all accumulated data to the workstation for permanent storage on hard disk.

3.03 SYSTEM CONFIGURATION BY OPERATORS

- A. Database Creation and Modification. All changes shall be done utilizing standard procedures and while the system is on-line and operational. The system shall allow changes to be made either at the local site through a portable computer or central workstation.
- B. The system shall permit the operator to perform as a minimum the following:
 - 1. Add and delete points
 - 2. Modify point parameters
 - 3. Create and modify control sequences and programs
 - 4. Reconfigure application programs
 - 5. Add and/or modify graphics.
- C. All data points within the database shall be completely accessible as independent or dependent variables for custom programming, calculation, interlocking, or manipulation.
- D. The graphics software shall permit the easy construction of infinitely variable shapes and sizes through the use of the mouse-pointing device.

A selection of 16 million colors and various fill textures, line types and text styles shall all be accessible through the use of the mouse interface. The software shall resemble many of the computer aided design programs currently available and allow graphics to be easily moved, edited, added or deleted. Graphics software shall be fully implemented and operational to accomplish the following:

1. Create a new graphic picture.
 2. Modify a portion of a graphic picture.
 3. Delete a graphic picture, or any portion thereof.
 4. Call up a graphic picture.
 5. Cancel the display of a graphic picture.
 6. Assign conditions, which automatically initiate the display.
 7. Overlay alphanumeric and graphics.
 8. Save the graphic picture.
 9. Display latest process data fully integrated with the graphic display.
 10. Display Live Graphical Software Programs.
- E. The workstation GUI software must be able to generate standard ASCII file formats to allow use with third-party software (Lotus 123, etc.) to generate and store owner-designed reports.

3.04 GRAPHICAL PROGRAMMING

- A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in standalone control modules. Any system that does not use a drag and drop method of graphical icon programming as described herein shall be unacceptable. Line by line computer code shall also be unacceptable. GPL is a method used to create sequence of operations by assembling graphic micro blocks that represent each of the commands necessary to complete a control sequence. Micro blocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each micro block shall be interactive and contain the programming necessary to execute the function of the device it represents.

Graphic programming shall be performed while on screen and using a mouse; each micro block shall be selected from a micro block library and assembled with other micro blocks necessary to complete the specified sequence. Micro blocks are then interconnected on screen using graphic "wires", each forming a logical connection. Once assembled, each logical grouping of micro blocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

The clarity of the graphic sequence must be such that the user has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the user with an understandable and exact representation of each sequence of operation.

Full simulation capability shall be provided with the graphic programming. User shall be able to fully simulate the constructed sequence on screen before the sequences are downloaded into the controllers. The System shall also include the ability to simulate multiple graphic programs communicating with each other on a simulated network. The simulation must show each output value and how it varies in relation to an artificial time clock. The time clock may run at normal time increments, increased increments (fast motion) or decreased increments (slow motion).

The following is a minimum definition of the capabilities of the Graphic Programming software:

1. Function Block (FB) - Shall be a collection of points, micro blocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O - Input/Output points which shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. BACnet Points - Shall be points that comply with the BACnet structure as defined in the same standard.

4. Micro blocks - Shall be software devices which are represented graphically and may be connected together to perform a specified sequence.
5. Wires - Shall be Graphical elements which are used to form logical connections between micro blocks and between micro blocks and logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.
6. Labels - Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
7. Parameter - A parameter shall be a value, which may be tied to the input of a micro block. Each parameter will then be displayed on the resulting FB parameter page and can be modified to varying degrees based upon the appropriate password level being used by the operator. Different parameter micro blocks shall be used depending on whether the parameter is digital or analog.
8. Constant - A constant shall be similar to a parameter except that it is displayed only in the graphic FB file itself and will not be displayed on any parameter page. Certain coefficients, which are used in various calculations always remain constant and therefore should be constants, which are embedded in the program and not parameters. Different constant micro blocks shall be used depending on whether the constant is digital or analog.
9. Properties - Dialog boxes shall appear after a micro block has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
10. Icon - An icon shall be graphic representation of a software program. Each graphic micro block has an icon associated with it, which graphically describes it function.
11. Menu-bar Icon - Shall be an icon, which is displayed on the menu bar on the GPL screen which represents its associated graphic micro block.
12. Passwords - Each micro block shall have its own assignable password level.

3.05 INFORMATION MANAGMENT SYSTEMS

A. Information Management Event Routing and Tracking Software

The Information Management System (IMS) event routing and tracking software shall be a comprehensive software package, a 32-bit application completely compatible with Internet Explorer Browser. It shall provide for creating alarming actions, generating alarm reporting actions, and configuring alarm and event views. The IMS software shall provide as a minimum the following features. Any system not meeting these minimum requirements shall be unacceptable.

1. Industry Standard Database Engine

The software shall utilize an industry standard database engine for all records associated with the IMS system. The database engine shall be compatible with Microsoft Access or SQL. These records shall be user configurable and capable of the following:

 - a. Operators- The operator record shall contain information on operators who will be using the IMS. Once an operator has been created, and if that operator has acknowledged any alarms, the operator record shall not be able to be erased unless and until all alarms acknowledged by that operator have been deleted from the system database. There shall be no limit to the number of operators that can be added to the system.
 - b. Passwords- Each operator must have a password. This password is used to log into the system and may also be required to acknowledge events, if the event has been so configured. The password shall be up to 8 characters in length.
 - c. Level- Each operator shall have a security level assigned. A security level is a number that defines a level of access in the IMS. This security level is also assigned to commands and events. An operator must have a security level equal to or greater than a command's security level in order to perform that command. Additionally, an operator must have a security level equal to or greater than an event's level in order to acknowledge that event or change the status of that event Reporting Action. The software shall provide for at least 100 security levels and be consistent with the security levels for the GUI.

- d. Systems - The Systems record shall allow the IMS software to have multiple systems or locations reporting to this one IMS database for alarm routing and management. An example would be multiple buildings located at multiple sites around the country. All these Systems shall be able to be integrated, by this software, into one IMS database record (in lieu of separate databases) for the purpose of information management routing and reporting.
- e. Reporting Actions- A Reporting Action shall be the automatic procedure that is launched (under certain conditions) after an event is received by the IMS workstation software. The operator shall have the capability to define when these Reporting Actions will be launched. Reporting Actions shall be associated with events through Reporting Groups. When the IMS receives an event, the operator shall have the capability to view the Reporting action status, as the Reporting Actions are launched and executed. An operator logged in at the receiving station shall have the ability to Abort or Execute the Reporting Action before its scheduled launch time if he/she has the proper security level. The following types of Reporting Actions shall be available:
 - 1. ASCII File Write - The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
 - 2. Numeric Pager- The numeric pager reporting action pages personnel by sending numeric messages to personal pagers through the use of a third-party service (definable and subscribed to by the operator). The numeric message may consist of numeric text entered by the operator and/or the Alarm ID and Alarm Priority. The operator shall be able to define how many times to attempt to connect to the pager service. The operator shall also be able to define a secondary number to call in case the connection to the first number is unsuccessful. The entire cycle of calling can be repeated for as many times as the operator defines, or until a successful page is completed. Unlimited numeric paging actions shall be defined.
 - 3. Parallel Printer - The parallel printer reporting action prints alarm information to a parallel printer. Unlimited parallel printing actions shall be defined.
 - 4. Email Output - The serial output reporting action sends alarm information to an email system. Software should be the email host and be able to process email notification directly without third party action. The Event/Alarm information is sent to the server and displayed on the screen. If previous Event/Alarm information has been sent, the new information is displayed starting at the next available line on the screen.
 - 5. Serial Output - The serial output reporting action sends alarm information to a Video Display Terminal (VDT), serial printer or other serial device. The terminal can be directly connected to the receiving station, or it can be accessed by a modem to modem connection. The Event/Alarm information is sent to the VDT and displayed on the screen. If previous Event/Alarm information has been sent, the new information is displayed starting at the next available line on the screen. The Event/Alarm information shall also be able to be sent by a modem-to-modem connection to a remote serial printer.
 - 6. Alphanumeric Pager- The alphanumeric pager reporting action shall page personnel from the receiving station using an alphanumeric paging system or a third party alphanumeric pager service (definable and subscribed to by the operator). The paging system can be directly connected to the receiving station, or it can be accessed by a modem to modem connection. The alphanumeric page that is sent shall be completely configurable by the operator. Up to 30 pagers shall be able to be contacted with a single connection to the paging unit. Only paging systems that use the TAP protocol shall be used. After an individual reporting action is configured by the operator, the operator shall have the ability to fully test this action within the IMS system. All actions shall be tested without the need for any real point events. There shall be unlimited alphanumeric pager reporting actions.
 - 7. Sound Play (.wav file) - The sound play reporting action shall play an operator defined .wav file when executed. If the station performing the sound play action does not have a

'sound' card, the computer speaker shall be used. All other operations shall pause for the duration of the .wav sound. There shall be unlimited sound play reporting actions.

8. SNMP output MIB- The system shall be capable of initiating a SNMP trap message to be exported to third party alarming systems such as Netcool, HP Openview and others.
9. Facsimile Reporting Action- The Facsimile Reporting Action (FRA) shall forward the assigned message to user specified numbers when the FRA executes. If the user defined default facsimile number is not reached successfully, the FRA will attempt alternative facsimile number destination until successful. There shall be unlimited facsimile reporting actions.

After an individual reporting action is configured by the operator, the operator shall have the ability to fully test this action within the IMS system. All actions shall be tested without the need for any real point events from control module field panels.

- f. Reporting Groups- Reporting Groups shall be created in order to efficiently organize various Reporting Actions. Reporting Actions are to be assigned to Reporting Groups in order to customize the routing of events/alarms reported to the IMS system. After a Reporting Group is configured with Reporting Actions, it shall be associated with individual event point records as necessary. When the IMS receives an event/alarm, it shall be routed to the designated Reporting Group and launch the designated Reporting Actions. There shall be no limitation to the number of Reporting groups that a user can define.

After a Group is configured with Reporting Actions, it can be associated with Alarm records when the alarm is configured.

- g. Critical Events/Non-critical Events - For remote system that rely on modem communications, events designated as 'critical' shall be delivered immediately. Non-urgent events shall wait until the system normally connects before delivering the message. All events generated at the DDC control module level shall comprise the following information:
 1. Time/Date Stamp using the standalone control module time/date
 2. Site location and network address
 3. Alpha-numeric event ID

The IMS system shall be capable of configuring an unlimited number of Event/Alarm conditions. For each Event, the following configurations selections shall be available as a minimum:

1. Multiline Text Field - Each Event shall have a multi-line text field. This information can be displayed with an Event/Alarm on the Main View of the IMS or sent to other destinations such as a serial printer. The system shall allow the operator to enter regular text in this field (for example, 'Boiler #3 has been shut down') and/or time, date and latched data values. Latched data values can be any digital or analog information available in the system which may have influenced the activation of that alarm/message. (i.e. a High Discharge Air Temperature alarm may also latch the current status of the Fan, Damper position, CFM, Cooling Valve position and Return Air Temperature). There shall be no limit to the length of the information which can be associated with an alarm. In addition, the operator shall have the option of selecting either single line or multi line display.
2. Reporting Group - The Reporting Group shall be used to associate an event record with a Reporting Group. Once an Event/Alarm is associated with a Reporting Group, any Reporting Actions associated with that Reporting Group shall be automatically launched when the IMS receives the event/alarm. As a minimum, the following three Reporting Groups shall be provided: Urgent Alarms, Alarms and Messages.
3. Priority- Priority shall define an event/alarms priority. The priority may be used as assorting criteria in the main view and shall have nothing to do with how quickly the IMS receives and displays an event. The priority level shall sort events/alarms in ascending order, commencing with '1'.

4. Security Level Field- The Security Level field assigns a numeric level of access to the alarm. An operator must have the same security level as an alarm or higher in order to acknowledge it and to change the alarm's Reporting Actions status. Security levels can range from 1-100, with '10' being the lowest and '100' being the highest.
 5. Acknowledge Required- If 'Yes' is selected, the operator shall be required to acknowledge the event when it is reported.
 6. Comment Required- If 'Yes' is selected, the operator shall be required to insert a comment as to what action will be taken as a result of the event or other pertinent information as required. There shall be no limit to the length of the comment, which shall be associated with the event.
 7. View Instructions- If 'Yes' is selected, the operator shall be required to view an instruction text that has been created and associated with the event. There shall be no limit to the length of the instruction, which can be associated with the event.
 8. Password - The IMS must require the operator to login, prior to acknowledgment of the event or other operator action.
- h. Maximum run time limits for all digital outputs and inputs shall be operator definable and shall be capable of automatically issuing a printed message when the run time maximum is exceeded. The operator shall be able to reset the run time accumulator.

B. IMS Main Display

The IMS software shall display the following information as a minimum:

1. Title bar located at the top of the display, which contains the name of the IMS station.
2. Menu bar with all the pull down selections available within the system. Menus shall include File, View, Actions, Configure and Help.
3. Events/alarms shall be displayed a format referred to as 'view'. Events shall be viewed either by date or those that require operator action.
4. Headers shall accurately describe the information displayed below the header, dependent on the 'view' selected by the operator.
5. Right mouse click menus that enable operators to perform operations quickly. These should include but not be limited to event acknowledgment, delete, view reporting status, force event return to normal, print, edit and view multi-line text.
6. The user shall be able to sort events in a 'To Do' list or display all events chronologically. Events shall be sorted by order of date or by those events that require operator or IMS intervention. Events, which require no further action, shall be displayed in the 'all by date' list.
7. The IMS toolbar shall provide the following buttons to access frequently used commands. Buttons shall be displayed in color when they are accessible and relevant to an operator's action, but grayed when they are not. The toolbar shall be toggled on/off by selecting view toolbar in the main menu.
8. The IMS toolbar shall provide the following buttons as a minimum:

Login/Logout	Print Event	Select View
Stop View Generation	Silence	Acknowledge Event
Reporting Action Status	Go To Event Graphic	Delete Event
Configure Events & Reporting	Configure Workstation	View Error Log
Context Sensitive Help		
9. The status line shall display various summary information about the activity of the IMS software and may be toggled off/on through the menu selection. As a minimum, the status of the following workstation options shall be displayed:

Receive Status (On/Off), Alarm Silenced (On/Off), Auto Delete (On/Off), Auto Delete (On/Off)

- a. The main IMS display shall also provide a numerical color-coded summary of the following:
 1. Number of events not yet returned to normal.
 2. Number of events requiring operator acknowledgement or other action.
 3. Number of events closed.

b. Handling Events/Alarms

1. Event/Alarm Receiving - When an event/alarm is received, it shall be possible to specify the following conditions before an event/alarm can be closed. For example, a Return (RTN) is normally required before the event/alarm can be closed.
 - i. Operator acknowledgement required
 - ii. Reporting action must be executed by IMS
 - iii. Event/alarm return to normal.
 - iv. Operator must read instructions
 - v. Operator/IMS must launch user specified commands
2. Multiple Event/Alarm Conditions- An event/alarm shall be capable of being configured with multiple conditions that must be fulfilled before it can be closed, including reporting actions executed by the IMS system such as output to a serial printer, numeric pager, event log, etc.
3. Reporting Action Status - Double clicking on the event/alarm in the Main View shall pop-up a Reporting Action Status dialog box detailing start time, end time and result of the designated reporting action.
4. Multi Line Text - Right-clicking on the Event/Alarm in the main view shall pop-up the multi-line text field describing the Event/Alarm.
5. Auto Delete - When enabled by the operator, the auto delete feature shall automatically delete closed Events/Alarms over ten days old, in order to conserve computer hard drive space.
6. Operator Commands - Operator commands shall executed from the menu or toolbar and are defined as follows:
 - i. Login / Logout - shall permit the operator to log into the IMS system, in order to execute operator actions such as event acknowledgment.
 - ii. Print Event - shall permit the operator to print to file or designated system printer a number of Event/Alarm pages.
 - iii. Select View - shall permit the operator to view all Events/Alarms by date or only those Events/Alarms that require operator or IMS action.
 - iv. Stop View Generation - shall permit the operator to freeze the current main view in order to read information as necessary.
 - v. Silence - shall permit an operator to halt audible notification. Event/Alarm acknowledgment shall automatically silence the audible alarm.
 - vi. Acknowledge Event - shall permit the operator to quickly perform Event/Alarm acknowledgment without multiple keystrokes or mouse operation.
 - vii. Reporting Action Status - shall permit the operator to view the start and end time of a designated reporting action and whether the result was successful.
 - viii. Go To Event Graphic - shall permit the operator to view the associated GUI graphic.
 - ix. Delete Event - shall permit the operator to delete the event/alarm from the main view and log.
 - x. Configure Events & Reporting - shall permit the operator to assign events and reporting actions to reporting groups, i.e. the operation shall be drag and drop using the workstation mouse.
 - xi. Configure Workstation - shall permit the operator to configure the following IMS software parameters as a minimum:
 - Appearance (Font, etc.)
 - Notification
 - Monitoring
 - Event Deletion (Auto-Delete)
 - Troubleshooting
 - xii. View Error Log - shall permit the operator to view the date and time of the reporting error in conjunction with a verbose description of the same.
 - xiii. Context Sensitive Help - shall permit the operator ready access to intuitive help menus including the use of help and a comprehensive Index.

3.06 DIRECT DIGITAL CONTROL SOFTWARE

- A. The system shall continuously perform DDC functions at the local Control Module in a stand-alone mode. The operator shall be able to design and modify the control loops to meet the requirements of the system being operated. The operators shall use system provided displays for tuning of PID loops. These displays shall include the past three input variable values, the setpoint for the loop as well as the sample interval and the results of the proportional, integral and derivative effects on the final output.
- B. Each Control module shall perform the following functions:
 - 1. Identify and report alarm conditions
 - 2. Execute DDC algorithms
 - 3. Execute all application programs indicated on the I/O Summary Table
 - 4. Trend and store data
- C. In the event of a Control module failure, all points under its control shall be commanded to the failure mode as indicated on the I/O Summary Table. All DDC software shall reside in the respective Control module. Power Failure/Automatic Restart:
 - 1. Power failures shall cause the Control module to go into an orderly shutdown with no loss of program memory.
 - 2. Upon resumption of power, the Control module shall automatically restart and printout the time and date of the power failure and restoration at the respective Workstation system.
 - 3. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

3.07 ELECTRICAL SYSTEM INTEGRATION

- A. Generator Fuel System
 - 1. Provide monitoring of fuel level and leak detection alarm system, fuel pumping system and day tank level and leak detection.
- B. Emergency Generator System
 - 1. System Description: The generator and generator switchgear shall communicate with the Building Management System via a manufacturer provided Programmable Logic Controller. The PLC communicates over a serial port using the Modbus protocol. Provide a portal to communicate between the Bacnet and Modbus protocols.
- C. Building Security
 - 1. There shall be no connection between the building security system and the Building Automation System.
- D. Leak Detection System
- E. Fire Alarm
- F. Main Switchboards
 - 1. System Description: Power Monitoring Package installed on Main Switchboards – A & B. Package communicates over a serial port using the Modbus protocol. Provide a portal to communicate between the Bacnet and Modbus protocols.
- G. UPS Modules and SCC, Switchboards and Power Meters

1. General: UPS Modules shall have portal to interface the UPS Modules with the BMS using the Bacnet protocol or equal.

H. Static Switches Serving UPS Bypass

1. General: Static Switches shall have communications port to interface the Static Switches with the BMS using the Bacnet protocol. All of the data, which is available at the Static Switches, shall be available at the operator workstation, via the BMS. All variables, which may be set at the Static Switches, shall be settable at the operator workstation, via the BMS.

END OF SECTION 16722

PART I - GENERAL1.01 RELATED DOCUMENTS

- A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 1, General Requirements, apply to the work of this Section.
- B. Manufacturer's Installation Manual.

1.02 DESCRIPTION OF WORK

- A. The new security system shall be located as indicated on the electrical drawings.
- B. Related Work Specified Elsewhere:
 - 1. Section 16010: General Requirements for Electrical Work
 - 2. Section 16120: Wire and Cables
- C. In accordance with the following codes, publications, and insuring authorities requirements, latest editions:
 - 1. National Electrical Code
 - 2. Underwriter's Laboratories, Inc. Publication

1.03 SUBMITTALS

- A. Submit for approval, prior to the start of installation, the following:
 - 1. Material and equipment information including catalog cuts and technical data for each component or device used in the system. This shall include, but is not limited to, the following:
 - a. Access control panels
 - b. Card readers
 - c. Exit push buttons
 - d. Electric door strikes
 - e. Magnetic door contacts
 - 2. Contractor shall provide information outlining the warranty of each system component.
 - 3. Sequences of operation, electrical schematics, and connection diagrams shall be provided to completely describe the operation and servicing of the security system.

PART II - PRODUCTS2.01 MANUFACTURERS

- A. Acceptable Manufacturers:
 - 1. Schlage Electronics
 - 2. Liebert
 - 3. Rusco
 - 4. Simplex
 - 5. Honeywell
 - 6. Cardkey, Inc.
 - 7. Substitutions under provisions of Section 01600

2.02 SPECIFICATION REQUIREMENTS

- A. The intent of this document is to specify the criteria for furnishing and installing an integrated Proximity Card Access control and Alarm monitoring system for indicated doors, monitor points, and approximately 50 employees. The system shall operate on the Proximity Principle where card insertion into a reading device is not required. The system shall also function as an alarm and contact monitoring system. System shall also function in an alarm central station access control mode. Individual contact points are supervised and may be selected for continuous monitoring, monitoring only upon command from an external switch, or by time period. The system shall consist of a wall-mount central controller, wall-mount proximity card readers, external keyboard and printer or CRT, up to 64 card reading sensors, and up to 64 contact monitoring modules of four circuits each. Up to 4,400 employee command key (card) codes (or 1200 codes with employee name) may be stored in memory.
- B. The system described shall include all necessary tools, equipment, material, and labor to furnish, install, and verify correct operation.
- C. The system supplier shall have a minimum of five years system design, engineering supervision, and installation experience in the alarm, building automation, or access control industry.

2.03 MAJOR EQUIPMENT LIST AND SPECIFICATIONS

- A. The central processor shall be a special purpose microcomputer. All memory functions shall be solid state with no loss of memory, including time and date, upon loss of the AC power.
- B. The central processor shall accommodate the following functions as a minimum:
 - 1. 64 proximity card reading sensors via external card reader modules. User assigned names up to 12 characters each.
 - 2. 255 monitored and supervised contacts via external contact monitoring modules. User assigned names up to 12 characters each.
 - 3. 4400 individually identified employees by 5 digit number (or alternate).
 - 4. 1200 individually identified employees by 5 digit number and a 12 character name.
 - 5. 50 user defined access codes (combinations of doors/time/days).
 - 6. 50 user defined holidays.
 - 7. 25 user defined combinations of activity reporting and contact operation.
 - 8. 8 output contacts, fused, non-latched.
 - 9. 1 output contact, fused, latched.
 - 10. 1 output port for local terminal, RS232C, with 100 message buffer and adjustable baud rate.
 - 11. 1 output port for remote terminal, RS232C, either direct connected or dial up, with 100 message buffer and adjustable baud rate.
 - 12. 5 connection ports for up to 8 external proximity card reading modules, with two adjustable baud rates.
 - 13. Provision for two external contacts designating desired building mode.

2.04 PROXIMITY CARD READER MODULE

- A. The proximity card reader module shall be a special purpose microprocessor based unit. It shall accommodate the following functions as a minimum:
 - 1. 8 external proximity card reading sensors connected via coaxial cable to the sensors.
 - 2. 8 external contact monitoring modules via the coaxial cable to the sensors.
 - 3. 8 lock output relays, 3 ampere, fused, with indicating lights.
 - 4. 2 ports for communicating with the central processor, selectable baud rate. One is 20 ma current loop, one is RS232C.
 - 5. Provision for anti-tamper and power fail inputs.
 - 6. Adjustable address, lock mode, unlock time, and diagnostics.

7. Provision for detecting failure of the sensor, coax, or contact monitor.
8. Specified - Select quantity based on number of sensors to be used (i.e.: 1 for each 8 sensors).

2.05 PROXIMITY CARD READING SENSORS

- A. The proximity card reading sensors are to be vandal proof and weatherproof sealed solid state units having no slots or other openings. It shall read the ID credential when it is held within 2" to 4" of its surface and transmit this unique ID to the proximity card reading module.
- B. The sensor design shall be such that it may be operated behind non-metallic surfaces. It may be surface-mounted on virtually any surface (including glass) without requiring cutouts or mounting bolts. Any sensor may be used in a normal mode or anti-pass back mode without changes to the reader. The sensors shall be designed to operate properly within the temperature range of -50° to +180° F and within a relative humidity range of 0% to 100%, condensing. No special housing or treatment shall be required for outdoor use.
- C. Physical damage, including breaking open of the sensor housing, shall not allow a perpetrator access to any circuitry that would allow the system to be compromised. Likewise, transmission of any frequency (or set of frequencies) into the sensor at any power level shall not compromise the system. Additionally, presentation of an invalid set of frequencies (such as would occur if a perpetrator were attempting to "pick" the system) shall temporarily disable the sensor - thus eliminating the possibility of "sweeping" the system and finding a valid combination.

2.06 PROXIMITY COMMAND KEY

- A. The ID credential shall be a credit card size passive component with the coding technique contained inside (i.e.: not visible from the outside). It shall be guaranteed for at least 5 years under normal use conditions. Each key shall contain a number not shared with any other key in that system. In addition, it shall have a unique facility code which identifies the end user's installation.
- B. The owner shall furnish to the contractor identification and logo information to be custom-printed on one/both sides of command keys.

2.07 CONTACT MONITORING MODULE

- A. The contact monitoring module provides for determining the status of external contacts that are part of the access and/or alarm system. It shall connect in the coaxial cable between the proximity card reader and the proximity sensor and receive all its power over that coaxial cable. Each module shall provide for connecting a maximum of four (4) dry (isolated) contacts to a maximum distance of at least 200 feet. Each contact shall be supervised against open or shorted conditions between the contact and the contact monitor.

2.08 TERMINAL

- A. The terminal shall provide the operator interface to the system, both for viewing the output messages or reports and for the input of commands or data. They shall be standard industry available units with 80 characters per line, standard ASCII character set and RS232C interface port. The operating speed of the terminals shall match the expected system usage.
- B. The terminal shall be a CRT, integral keyboard and a separate printer using fan-fold paper. It shall be capable of operating at 120 characters per second.

2.09 MODEMS

- A. Modems shall provide for operating the remote terminal over the public dial telephone network. The modems shall have a protocol that operates with the central processor. The central processor shall store the telephone number (s) to be dialed and shall control the number of dial attempts.

2.10 POWER MODULES

- A. The power modules shall provide for converting the available commercial power to the power required by the central processor and proximity card readers, as well as power on/off switching, fault protection, and power on indication. The wiring between the power module and the powered device shall be integral and require only a plug in connection.
- B. The power module shall be of the non-interruptive type with an external sealed battery to maintain operation during power outages. Battery size is to be for 15-minutes of operation.

2.11 SYSTEM OPERATION

- A. The following is a minimum list of functions that the system shall provide after installation and before acceptance by the owner.
1. Add keys to memory with ability to define where and when the key holder may use the key. On a door-by-door basis, valid access times and days shall be definable.
 2. Group load keys with the same access control privileges using any sensor.
 3. Delete keys from memory.
 4. Modify access control privileges of individual keys.
 5. Define which keys are selected for tracing.
 6. Define certain keys as "night" (privileged) keys - allowing access to "night" sensors when the alarm system is in the "night" mode.
 7. Define the system configuration data (i.e.: which doors are active IN and OUT doors, relationship of doors and contact points, etc.).
 8. Define which door (s) will have request-to-exit (alarm shunt) implemented.
 9. Define which monitored door (s) will alarm when "forced" open and during what time such alarms will take place.
 10. Select card controlled areas that are to operate in an anti-passback mode and whether contact closure is required to change anti-passback status.
 11. Manually unlock doors from the terminal.
 12. Define up to 50 access codes (groups of doors with up to 4 time/day codes associated with each door).
 13. Define up to 50 holidays.
 14. Automatically unlock and relock selected locks by time/day code.
 15. Define which sensors are "night" mode (building closed) sensors.
 16. Define which sensors are "switch" sensor which an enable or disable the "night" mode of operation (i.e.: enable and disable the alarm system).
 17. Select sensors that will generate an alert message when key codes selected for trace are used.
 18. Obtain hard copy listings of key codes by any combination of access code, location (in or out), privileged (night mode) and trace status.
 19. Obtain hard copy listings of each report type.
 20. Define pass codes and up to 6 levels of access for operator entry into system command mode.
 21. Obtain hard copy report of current system status.
 22. Select access and monitor point activity messages that are output to the system printer (s).
 23. Determine if valid access reporting is required only at certain hours of the day and week for selected sensors.
 24. Acknowledge alarm conditions.
 25. Select which monitor points are to be monitored at all times and which require external enabling (night mode).

26. Select which monitor points are to be monitored at all times and which are monitored only during selected time periods.
27. Select which door (s) and monitor point (s) will actuate output contact (s) on the central processor.
28. Select which monitor points are to generate a latched alarm and which are to report for information purposes only.
29. Define under what circumstances the system will "dial up" and report to the central station.
30. Define up to 3 telephone numbers for dial-up use.
31. Define how many attempts (up to 10) will be made to communicate via dial-up.
32. Define when the system will report that building close is overdue.
33. Define a 12 character name for each monitor point and each sensor.
34. Define a 12 character name for each employee (if 1200 or fewer key codes are to be stored in memory).
35. Define a 12 character name for each operator.
36. Select card controlled areas that are to be monitored for "forced" and "door held open" alarms, and whether such alarm will be generated at all times or only when the system is in "night mode".

2.12 MESSAGES

- A. All system activity messages to the operator shall be in plain English language text. Mnemonic or transaction code type operator messages are not acceptable.

2.13 MENU DRIVEN INTERFACE

- A. All operator commands shall be accomplished by selecting from a "menu" on the terminal. Command descriptions in the "menu" shall be such that an operator will generally not require an instruction manual to execute authorized system commands. However, a complete operator's manual shall also be supplied.
- B. A password must be used by an operator to gain access to system commands. Each password shall be assigned to 1 of 6 command levels. A command level is a set or sub-set of all system commands. It shall be possible to define up to 8 passwords.

2.14 TEST PROCEDURES

- A. The contractor shall supply a proposed acceptance test procedure.

PART III - EXECUTION

3.01 INSTALLATION SUPERVISION

- A. The contractor shall provide on the job site a factory-trained technician to assist and advise installing personnel. All final connections shall be made under the direct supervision of the contractor. Testing of the system shall be the sole responsibility of the contractor.
- B. A final test for acceptance shall be performed by the contractor.

3.02 TRAINING

- A. After acceptance, contractor shall provide complete detailed "as-built" drawings, written operation instructions, and manuals. He shall conduct a minimum one day course for system operators and users.

3.03 SERVICE

- A. The contractor must employ a factory-trained service organization within 60 miles of the job site. This organization shall have had a minimum of five years experience in servicing access control and alarm equipment.

3.04 WIRING REQUIREMENTS

- A. All wiring incidental to the protection system shall be provided by the Electrical Contractor.
- B. Detailed wiring diagrams and necessary job site supervision shall be provided by the contractor. The term "wiring" shall include furnishing of wire, conduits, miscellaneous materials, and labor as required for connecting the system equipment.
- C. Installation shall be done under system manufacturer's requirements.
- D. System shall interface with building fire alarm system to release doors into fail-safe conditions upon alarm.

END OF SECTION 16731

PART I - GENERAL1.01 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

- A. ANSI C2-1987: ANSI/IEEE National Electrical Safety Code
- B. ANSI C62.41-1980: Guide for Surge Arrestors, Voltage, and Low Voltage AC Power Circuits
- C. EIA-170: Electrical Performance Standards - Monochrome Television Studio Facilities
- D. EIA-330: Electrical Performance Standards for Closed Circuit Television Camera 525/60 Interlaced 2:1.
- E. EIA-RS-375-A: Electrical Performance Standards for Closed Circuit Television Camera 525/60 Interlaced 2:1.
- F. EIA-310-C: Racks, Panels, and Associated Equipment
- G. EIA-232-D: Interface Between Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary Data Interchange.
- H. IEEE 503-1978: IEEE Standard for Measurement and Characterization of Diode-Type Camera Tubes
- I. IEEE 142-1982: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- J. NEMA 250-1985: Enclosures for Electrical Equipment (1000 Volts Maximum).
- K. NFPA 70-1987: National Electrical Code
- L. UL 1410: Television Receivers and High Voltage Video Products.
- M. UL 6: Rigid Metal Conduit (October 23, 1981, 9th Ed.; Rev. October 10, 1983)
- N. FCC Rules and Regulations and Amendments as found in Code of Federal Regulations Title 47, Part 15: Subpart C-Radio Receivers Subpart H-TV Interface Devices Subpart Computing Devices.

1.02 SYSTEM DESCRIPTION

- A. General: The Contractor shall configure the system as described and shown. All television equipment shall conform to EIA-170 specifications. The system shall include all connectors, adapters, and terminators necessary to interconnect all equipment. The Contractor shall also supply all cabling necessary to interconnect the closed circuit television (CCTV) equipment installed to establish a complete operational system.
- B. Environmental Conditions
 - 1. Exterior Equipment: The cameras and all other exterior equipment shall be rated for continuous operation under ambient environmental conditions of 14° to 120° F. Equipment shall be rated for continuous operation under the ambient environmental temperature, humidity, wind loading, ice loading, and vibration conditions specified or encountered for the installed location.
 - 2. Interior Equipment: Interior equipment shall, unless designated otherwise, be rated for continuous operation under ambient environmental conditions of 60° to 85° F and a relative humidity of 20 to 80 percent.

- C. Power Line Surge Protection: All equipment connected to ac power shall be protected from surges. Equipment protection shall meet the requirements of ANSI C62.41. Fuses shall not be used for surge protection.
- D. Video and Sync Signal Transmission Line Surge Protection: All cable, except fiber optic cable, used for sync or video signal transmission shall include protective devices to safeguard the CCTV equipment against surges. The surge suppression device shall not attenuate or reduce the video or sync signal under normal conditions. The surge suppression device shall be capable of dissipating not less than 1500 watts for 1 millisecond, and the response time from zero volts to clamping shall not be greater than 5 nanoseconds. Fuses shall not be used for surge protection.
- E. Control Line Surge Protection: All cables and conductors, except fiber optic cables, which serve as communication, control, or signal lines shall be protected against surges and shall have surge protection installed at each end. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following waveforms:
 - 1. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
 - 2. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.03 DELIVERY OF TECHNICAL DATA

All items of technical data, which are specifically identified in this specification, will be delivered strictly in accordance with the requirements listed below.

- A. System Drawings: The data package shall include the following:
 - 1. System block diagram
 - 2. CCTV system console installation, block diagrams, and wiring diagrams
 - 3. Security Center CCTV equipment installations, interconnection with console equipment, block diagrams, and wiring diagrams.
 - 4. Camera wiring and installation drawings.
 - 5. Interconnection with video signal transmission system, block diagrams, and wiring diagrams.
 - 6. Surge protection device installation.
- B. Manufacturer's Data: The data package shall include manufacturer's data for all materials and equipment and security center equipment provided under this specification.
- C. System Description and Analysis: The Group 1 data package shall include complete system descriptions, analyses and calculations used in sizing the equipment required by these specifications. Descriptions and calculations shall show how the equipment will operate as a system to meet the performance of this specification. The data package shall include the following:
 - 1. Switcher matrix size.
 - 2. Camera call-up response time.
 - 3. System start-up and shutdown operations.
 - 4. Switcher programming instructions.
 - 5. Switcher operating and maintenance instructions.
 - 6. Manuals for CCTV equipment.
 - 7. Data entry forms.

- D. Certifications: All specified manufacturer's certifications shall be included with the data package.
- E. Operation and Maintenance Manual.

END OF SECTION 16751

PART I - GENERAL1.01 REFERENCE

A. The publications listed below form a part this specification to extent referenced. The publications are referred to in the text by the basic designation only.

1. ANSI C2-1987- National Electrical Safety Codes
2. ANSI C62.41-1981 - Guide for Surge Voltage in Low-Voltage AC Power Circuits
3. ANSI X3.64-1979 - Additional Controls Used with American National Standard Code for Information Interchange (ASCII)
4. ANSI X4.14-1971 - Alphanumeric Keyboard Arrangements Accommodating the Character Sets of ASCII and ASCSOR
5. ANSI X4.16-1983 - American National Standard for Financial Services - Financial Transaction Cards- Magnetic Stripe Encoding
6. EIA 232-D - Interface between data terminal equipment and data circuit - terminating equipment employing serial binary data
7. EIA 310-C - Tacks, Panels and Associated Equipment
8. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION 46
9. IEEE 100-84 - IEEE Standard Dictionary of Electrical and Electronic Terms
10. IEEE 142-82 - Recommended Practice for Grounding of Industrial and Commercial Power Systems
11. IEEE 229-69 - Recommended Practice for Measurement of Shielding Effectiveness of high Performance Shielding Enclosures
12. NEMA 250-1985 - Enclosures for Electrical Equipment (1000 Volts Maximum)
13. NFPA 70-1987 - National Electrical Code
14. 13. UL 294 - Access Control System Units (16 January 1987)
15. FCC Part 15 - Radio Frequency Devices (October 1987)

1.02 SYSTEM DESCRIPTION

A. General: The Contractor shall configure the electronic entry control system (EECS) as a modular, digital-computer-based, distributed architecture network as specified and shown including government furnished equipment. The EECS shall provide operator interface, interaction, and dynamic real-time process manipulation, including overall system supervision, coordination and control. Computing devices, as defined in FCC Rules and Regulations, Part 15, shall be certified to comply with the requirements for Class A or Class B computing devices and labeled as set forth in FCC Rules and Regulation, Part 15. Electronic equipment shall comply with FCC Regulation part 15.

1.03 ENVIRONMENTAL CONDITIONS

- A. Interior, Controlled Environment: All system components except the security console equipment installed in interior locations having controlled environments shall be rated for continuous operation under ambient environments shall be rated for continuous operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 20 to 90 percent relative humidity, non-condensing.
- B. Interior, Uncontrolled Environment: All system components installed in interior locations having uncontrolled environments shall be rated for continuous operation under ambient environmental conditions of 0 to 120 degrees F dry bulb and 10 to 95 percent relative humidity, non -condensing.
- C. Console: All console equipment shall, unless designated otherwise, be rated for continuos operation under ambient environmental conditions of 60 to 85 degrees F and a relative humidity of 20 to 80 percent.

1.04 ALARM CLASSIFICATION

Definitions and requirements apply to EECS and equipment.

- A. **FAIL SAFE ALARM:** The EECS shall include a fail-safe capability in its critical system functions. The EECS shall monitor for proper system functions and to report an alarm when a failure is detected. This shall include, but not be limited to, the capability to monitor communication circuit integrity and to provide self-test. When diminished functional capabilities are detected, the system shall annunciate the fault.
- B. **POWER LOSS ALARM:** The EECS shall detect when system components experience loss of power exceeding 2 seconds, and shall annunciate an alarm. The alarm shall annunciate an alarm. The alarm shall identify the zone experiencing the power loss. Circuitry shall be designed to fail to an alarm condition with the loss of power.
- C. **ACCESS CONTROL ALARM:** An access control alarm shall be annunciated when the EECS detects improper use of EECS procedures or equipment.
- D. **INTRUSION ALARM:** An intrusion alarm shall be annunciated by the EECS when entry into access controlled area is attempted without using EECS procedures.
- E. **FALSE ALARM:** The annunciation of any alarm when there is no alarm stimulus.
- F. **ENVIRONMENTAL ALARM:** The annunciation of a false alarm during environmental conditions that exceed those specified.
- G. **NUISANCE ALARM:** The annunciation of an alarm resulting from the detection of an alarm stimulus, but which does not represent an attempt to intrude into the protected area.
- H. **DETECTION RESOLUTION:** The system shall have detection resolution sufficient to:
 - 1. Locate intrusions at each device and zone
 - 2. Locate failures or tampering at individual devices
- I. **ALARM DETECTION AND REPORTING CAPACITY:** The EECS shall have the capacity to collect, communicate and display up to 20 alarms. The system shall maintain the capability to identify individual sensors, switches, and terminal devices in an alarm state. A single alarm shall be annunciated within 2 seconds, after sensor, transducer, terminal device or other device activation.

1.05 INTEGRATED SYSTEM PERFORMANCE REQUIREMENTS

- A. The installed and operating EECS shall perform as complete and integrated system as specified.

1.06 ERROR AND THROUGHPUT RATES

Error and throughput rates shall be single portal performance rates obtained when processing individuals one at time. If serial verification techniques or multiple attempts are required to satisfy error performance requirements, these features shall not reduce the capability to meet throughput requirements.

- A. **TYPE I ERROR RATE:** A Type I error denies access to an authorized, enrolled individual. The EECS Type I error rate shall be less than 1 percent.
- B. **TYPE II ERROR RATE:** A Type II error grants access to an unauthorized individual. The EECS Type II error rate shall be less than 0.001 percent.

- C. SYSTEM THROUGHPUT: At specified error rates, the system throughput rate through a single portal shall be as shown.

1.07 SYSTEM REACTION

- A. SYSTEM RESPONSE: All alarms shall be annunciated on the console within 2 seconds of them occurring at a local processor or devices controlled by a local processor and within 100 milliseconds if the alarm accrues at the control processor. Alarm and status changes shall be displayed within 100 milliseconds after receipt of data by the central processor. This response time shall be maintained during system heavy load.
- B. SYSTEM HEAVY LOAD DEFINITION: System heavy load conditions are defined as the occurrence of alarms at the rate of 10 alarms per second distributed evenly among all local processors in the system. The alarm printer shall continue to print out all occurrences, including time of occurrence, to the nearest second.

1.08 ELECTRICAL REQUIREMENTS

- A. EECS equipment shall operate on 120 volt ac sources as shown, plus or minus 10 percent, and 60 Hz plus or minus 2 percent.

1.09 POWER LINE SURGE PROTECTION

- A. All equipment connected to alternating current circuits shall be protected from power line surges. Equipment protection shall meet the requirements of ANSI C62.41. Fuses shall not be used for surge protection.

1.10 DEVICE WIRING SURGE PROTECTION

All inputs shall be protected against surges induced on device wiring. Outputs shall be protected against surges induced on control and device wiring installed outdoors and as shown. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

- A. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
- B. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.11 COMMUNICATION CIRCUIT SURGE PROTECTION

All communications equipment shall be protected against surges induced on any communications circuit. All cables and conductors, except fiber optics, which serve as communications circuits from security console to field equipment, between field equipment, shall have surge protection circuits installed at each end. Protection shall be furnished at equipment, and additional triple electrode gas surge protectors rated for the application on each wire line circuit shall be installed within 3 feet of the building cable entrance. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal and common mode using the following two waveforms:

- A. A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
- B. An 8-microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.12 DELIVERY OF TECHNICAL DATA

All items of technical data, which is specifically identified in this specification, will be delivered strictly in accordance with the requirements listed below:

A. System Drawings: The data package shall include the following:

1. System block diagram
2. Console installation, block diagrams, and wiring diagrams
3. Local processor installation, typical block, and wiring diagrams
4. Local processor physical layout and schematics
5. Device wiring and installation drawings
6. Details of connections to power sources, including power supplies and grounding
7. Details of surge protection device installation
8. Details of interconnections with IDS and /or CCTV system.

B. Manufacturer's Data: The data package shall include manufacturer's data for all materials and equipment, including terminal devices, local processors and security center equipment provided under this specification.

C. System Description and Analyses: The data package shall include system descriptions, analyses, and calculations shall show how this specification. The data package shall include the following:

1. Central processor memory size
2. Communication speed and protocol description
3. Rigid disk system size and configuration
4. Flexible disk system size and configuration
5. Alarm response time calculations
6. Command response time calculations
7. System throughput calculations
8. Startup operations
9. Expansion capability and method of implementation
10. Sample copy of each report specified

D. Software Data: The data package shall consist of descriptions of operation and capability of system, command, and application software as specified.

E. Certifications: All specified manufacturer's certifications shall be included with the data package

F. Data Entry: The Contractor shall enter all data needed to make the system operational. The Contractor shall deliver the data to the Owner on data entry forms, utilizing data for the owner's documents, Contractor's field surveys, and all other pertinent information in the Contractor's possession required for complete installation in the Contractor's possession required for complete installation of the data base. The Contractor shall identify and request form the Owner's, and additional data needed to provide a complete and operational EECS. The completed forms shall be delivered to the Owner's for review and approvals at least 30 days prior to the Contractor's scheduled need date.

G. Graphics: Where graphics are required and are to be delivered with the system, the Contractor shall create and install all graphics needed to make the system operational. Graphics shall have sufficient level of detail for the system operator to assess the alarm. The Contractor shall supply hard copy; color examples at least 8 inches by 10 inches in size, of each type of graphic to be used for the completed EECS. The graphic examples shall be delivered to the Owner for review and approval at least 30 days prior to the Contractor's scheduled need date.

- H. Functional Design Manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.
- I. Hardware Manual: A manual describing all equipment furnished including:
1. General description and specifications
 2. Installation and checkout procedures.
 3. Equipment electrical schematics and layout drawings.
 4. System schematics and layout drawings.
 5. Alignment and calibration procedures.
 6. Manufacturer's repair parts list indicating sources of supply.
 7. Interface definition.
- J. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing and operation. The manual shall include:
1. Definition of terms and functions.
 2. Use of system and applications software.
 3. Procedures of r system initialization, startup and shutdown.
 4. Alarm reports.
 5. Report generation.
 6. Data base format and data entry requirements.
 7. Directory of all disk files.
 8. Description of all communications protocols, including data formats, command characters, and a sample of each type of data transfer.
- K. Operator's Manual: The operator's manual shall fully explain all procures and instructions for the operation of the system including:
1. Computers and peripherals.
 2. System startup and shutdown procedures.
 3. Use of system, command, and applications software.
 4. Recovery and restart procedures.
 5. Graphic alarm presentation.
 6. Use of report generator and generation of reports.
 7. Data Entry.
 8. Operator commands.
 9. Alarm messages and printing formats
 10. System access requirements
- L. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
- M. As-Built Drawings: The Contractor shall maintain a separate set of drawings, elementary diagrams and wiring diagrams of the EECS to be delivered as "as-built: drawings. This set shall be accurately kept up to date by the Contractor with all changes and additions to the EECS and shall be delivered to the Owner upon completion.

1.13 TESTING

- A. General: The Contractor shall perform; site testing, and adjustment of the completed EECS. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing. Written notification of planned testing shall be given to the Owner at least 14 days prior to the test and in no case shall notice be given until after the Contractor has received written approval of the specific test procedures. Test procedures shall explain in detail, step-by-step actions and expected results demonstrating compliance with the requirements of the specification. Test reports shall be used to document results of the tests. Reports shall be delivered to the Owner within 7 days after completion of each test.

1.14 TRAINING

- A. General: The Contractor shall conduct training for designated personnel in the maintenance and operation of the EECS as specified. The training shall be oriented to the specific system being installed under this contract. Training manuals shall be delivered for four (4) trainees with two additional copies delivered for archiving at the project site. The manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. The Contractor shall furnish audiovisual equipment and other training materials and supplies. Where the Contractor presents portions of the course by audiovisual materials, copies of the audiovisual material shall be delivered to the Owner either as apart of the printed training manuals or on the same media as that used during the training sessions. This training shall include:

1. General EECS Hardware Architecture.
2. Functional operation of the system.
3. Operator commands.
4. Data base entry.
5. Report generation.
6. Alarm reporting.
7. Diagnostics.

1.15 LINE SUPERVISION

- A. Signal and DTM Line Supervision: All signal or DTM lines between terminal devices and local processors, and lines to the EECS central processor and alarm annunciation console shall be supervised by the changes or disturbances in the signal and for conditions as described in UL 1076 for line security equipment. The EECS shall also monitor circuits for loss of signal or a change in signal level greater than 10 percent. An alarm shall be annunciated at the console if any of these conditions occur.
- B. Data Encryption: The EECS shall incorporate data encryption equipment on data transmission media circuits as shown. The algorithm used for encryption shall be the Data Encryption Standard (DES) algorithm describe in Federal Information Processing Standards Publication 46

1.16 DATA TRANSMISSION MEDIA (DTM)

The Contractor shall provide DTM systems as required by manufacturer of system.

PART II – GENERAL REQUIREMENTS**2.01 GENERAL REQUIREMENTS:**

- A. Materials and Equipment: Units of the same type of equipment shall be products of a single manufacturer. All material and equipment shall be new and currently in production. Each major component of equipment shall have the manufacturer's model and serial number in conspicuous place.

Equipment shall conform to UL 294 and UL 1076. Equipment located at the Security Center or at a remote control/monitoring station shall be rack mounted as shown.

- B. Hardware Manufacturer Experience: All system and application software shall be produced by manufacturers regularly engaged in the production of EECS components for at least 5 years.
- C. Software Manufacturer Experience: All system and application software shall be produced by manufacturers regularly engaged in the production of EECS and application software for at least 2 years.
- D. System Installer Experience: The system shall be installed by a Contractor who has been regularly engaged in the installation EECS equipment for at least 2 year
- E. System Component Design: EECS components shall be designed for continuous operation. Electronic components shall be solid state type, mounted on printed circuit boards conforming to UL 796. Printed circuit board connectors shall be plug-in, quick-disconnect type. Power dissipating components shall incorporate safety margins of not less than 25 percent with respect to dissipation ratings, maximum switching devices shall be solid state type or sealed electromechanical.
 - 1. Modularity: The Contractor shall provide equipment designed for increase of system capability by installation of component modules. System components shall be designed to facilitate maintenance through replacement of modular subassemblies and parts.
 - 2. Maintainability: Components shall be designed to be maintained using commercially available tools and equipment. Components shall be arranged and assembled so they are accessible to maintenance personnel. There shall be no degradation in tamper protection, structural integrity, EMI/RFI attenuation, or line supervision capability after maintenance when it is performed in accordance with manufacturer's instruction. The system shall be configured and installed to yield a mean time to repair (MTTR) of not more than 8 hours. Repair time is the clock time from the time maintenance personnel are given entrance to the EECS and begin work, until the EECS is fully functional.
 - 3. Interchange ability: The system shall be constructed with off-the-shelf components that are physically, electrically and functionally interchangeable with equivalent components as complete items. Replacement of equivalent components as complete items. Replacement of equivalent components shall not require modification of either the new component or of other components with which the replacement items are used. Custom designed or one-of-a-kind items shall not be used. Interchangeable components or modules shall not require trial and error matching in order to met integrated system requirements, system accuracy, or restore complete system functionality.
 - 4. Electromagnetic and Radio Frequency Interference (EMI/RFI): EECS components generating EMI/RFI shall be designed and constructed in accordance with IEEE No. 299, IEEE No. 692, and shall be FCC licensed an approved.
 - 5. Product Safety: EECS Components shall conform to applicable rules and requirements of NFPA 70 and UL 294. EECS components shall be equipped with instruction plates including warnings and cautions, describing physical safety, and special or important procedures to be followed in operating and servicing EECS equipment.
- F. Enclosures: System enclosures shall be metallic.
 - 1. Interior Terminal Device Enclosures: All terminal devices to be used in an interior environment shall be housed in an enclosure that provides protection against duct, falling dirt, and dripping non corrosive liquids.
 - 2. Interior Enclosures: All system electronics to be used in a interior environment shall be housed in enclosures which meet the requirements of NEMA 12 as specified in NEMA 250
- G. Nameplates: Nameplates shall be provided for EECS equipment and devices. Laminated plastic nameplates shall be provided for central and local processors. Each nameplate shall identify the processor and its location within the system. Laminated plastic shall be 1/8 inch thick, white with black

center core. Nameplates shall be a minimum of 1 inch by 3 inches, with minimum ¼ inch high engraved block lettering. Nameplates shall be attached to the inside of the enclosure housing the local processor. Other major components of the system shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a corrosion resistant plate secured to the item of equipment. Nameplates shall not be required of devices smaller than 1 inch by 3 inches.

2.02 ELECTRONIC ENTRY CONTROL SYSTEM OPERATION:

- A. General: The Contractor shall furnish the EECS complete and ready for operation. The EECS shall operate in a continuous interrogation, control, and response mode. The EECS shall provide a user interface and an operator interface to control system functions. The EECS shall provide a means to enter time, date, and installation related data such as portal numbers, portal descriptors, central processor addresses, and local procedure addresses. Under normal operations, the EECS shall record transactions as they occur. This record shall include identification of the individual, location, time of day, and date. If access is denied, an access denial alarm shall be initiated and the EECS shall record reason for denial.
1. Definition of EECS Identifiers: An identifier shall be a card credential, keypad personal identification number or code, biometrics characteristic or any other unique identification number or code, biometrics characteristic or any other unique identification entered as data into EECS database for the purpose of identifying an individual. Identifiers shall be used by the EECS for the purpose of validating ingress and egress requests for areas under the control of the EECS
 2. Definition of Devices: A terminal device shall be any piece of equipment which gives a user the means to input identification data into the EECS of verification. A facility interface device shall be any type of mechanism which is controlled in response to ingress or egress request and allows passage through a portal.
- B. User Interface: The EECS shall control ingress and egress. The decision to grant or deny ingress or egress shall be based upon identifier data to be input at a specific location during the current time period. If all conditions are met, a signal shall be sent to the input device location to activate the appropriate electric strike, bolt, electromagnetic lock or other type of portal release of facility interface device.
- C. System Operator Interface: EECS operation shall be entirely automatic under control of the EECS central processor (s) and local procedures except for simple control key operations required for map display, alarm acknowledgment, zone and portal status change operations, audible or visual alarm silencing and audio annunciation. The EECS shall immediately annunciate changes in zone and portal status. The unit printer shall print a permanent record of each alarm and status change. The map displays or graphics screen shall display the current status of EECS zones and portals installed on the map display screen. The EECS shall immediately display the current status of any zone or portal upon command. While the EECS is annunciating an unacknowledged zone or portal alarm, keyboard operations at the system operator console other than alarm acknowledgment shall not be possible. The EECS shall provide the capability to change zone and portal status from alarm (after alarm acknowledgment) or access to secure, from alarm (after alarm acknowledgment) or secure to access, or from access to secure by simple control operations. If the operator attempts to change zone status to secure while there is an alarm output for that zone or portal, the EECS shall immediately annunciate an alarm for that zone or portal.
- D. Enrollment Operator Interface: Enrollment stations shall be provided and located as shown. The enrollment station may be the same equipment designated for use as the system operator interface. All hardware and software needed to create the data for enrolling or disenrolling a person in the EECS shall be provided as part of the enrollment station. The enrollment station shall provide database management functions for the EECS, and shall allow an operator to change and modify the data entered in the EECS as needed. Multiple password protected access levels shall be provided at the enrollment station. Database management and modification functions shall require a high operator access level that personnel enrollment functions. A printer shall be provided for the enrollment station.

- E. Electronic Entry Control System Functions: The EECS shall implement the following functions under system manager/operator control:
1. Multiple Security Levels: The EECS shall have multiple security levels. Each of the security levels shall be delineated by facility barriers using designated EECS procedures. The EECS design shall provide at least 8 security levels. Any attempt to access an area beyond the individual's predefined security level shall initiate an access denial alarm.
 2. Anti-Passback: Portals as shown shall incorporate anti-passback functions. Anti-passback functions and identifier tracking shall be system-wide for all portals incorporating anti-passback. Once an authorized, enrolled individual has passed through a portal using EECS procedures, the system shall not allow use of the same identifier to pass through any portal at this same security level using EECS procedures. Any attempt to violate anti-passback procedures shall initiate an access denial alarm. Portals that do not incorporate anti-passback functions shall allow egress from the area.
 3. Immediate Access Change: The EECS shall provide functions to disenroll and deny access to any identifier or combination of identifiers without consent of the individual or recovery of a credential. The design of the EECS shall provide access change capability to system operators and managers with appropriate password clearance at the system operator console.
 4. Identifier and Terminal Tracking: The EECS shall track the movements and activity of an identifier throughout the site at any terminal device. The EECS shall use this data to generate, and store a log of this activity. The log shall be updated every time a transaction involving an identifier or terminal device is completed. The design of the EECS shall provide identifier tracking data for at least 1 year, and terminal device tracking for at least 1000 transactions without loss of log data. The EECS shall be able to provide hard copy report generation for the log of each type of identifier and terminal device.
 5. Automatic Activation and Deactivation of Credentials: The EECS shall provide automatic activation and deactivation of access authorization for personnel enrolled in the EECS.
 6. Multiple Time Zones: The EECS shall provide multiple time zone access control. Personnel enrolled in the EECS shall only be allowed access to a facility during the time of day they are authorized to access the facility. Time zone access control shall also include the ability to specify beginning and ending dates that an individual will be authorized to access a facility. The design of the EECS shall provide at least 4 time zones with overlapping time zones. The EECS shall provide a means for system operators with proper password clearance to define custom names for each time zone, and to change the time zone's beginning and ending times through the operator interface. The EECS shall automatically disenroll individuals at the end of their predefined facility access duration. Any attempt during a 24 hour period by an individual or an identifier to gain facility access outside of the authorized time zone shall initiate an access denial alarm.
 7. Multiple Operator Levels: The EECS shall provide a means to define system operator capability and functions through multiple, password protected operator levels. At least 3 operator levels shall be provided. System operator and managers with appropriate password clearance shall be able to change operator levels for all operators. Three successive attempts by an operator to execute functions beyond their predefined capability during a 24 hour period shall initiate a software tamper alarm.
 8. Output Relay Control: The EECS shall provide a means to individually control and monitor the state of all output relays.
 9. Hard copy Report Generation: The EECS shall be able to generate hard copy reports of identifier, terminal, and versions with defined parameters of the manufacturer's standard management and activity reports.
 10. Enrollment: The EECS shall provide a method to enter personnel identifying information into the EECS database files through enrollment stations. In case of personnel identity verification subsystems, this data shall include biometrics data. The EECS shall allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names shall be customized to suit user and site needs. The Contractor shall insure that any personnel identity verification subsystems selected for use with the EECS will fully support the enrollment function and are compatible with the EECS database files.

- F. Electronic Entry Control System Capacities: The EECS shall be designed and configured to provide the following capacities:
1. Enrollees: The EECS shall be configured for 300 enrollees. The EECS shall provide a facility tailorable reference file database containing personal, access authorization, identifier and verification data for each enrollee as required.
 2. Transaction History File Size: The EECS capacity shall be at least the amount of transaction calculated for the system during 1 year without any loss of transaction data.
 3. Number of Portals: The EECS shall monitor and control the portals shown. The system shall be able to control at least 10 additional portals by adding terminal devices, local processors, and wiring as needed.
 4. Number of Output Relays: The EECS shall monitor and control the number of output relays shown.
- G. Local Processor Interrogation: The EECS shall interrogate each local processor in the system until all processors in the system have been interrogated. The interrogation shall be repeated on a continuous basis. The EECS shall complete each interrogation cycle of all EECS local processors and associated zones and portals, and show the status exclusive of new data exchange. The local processor shall exchange new data with the central processors as needed during each polling sequence. Alarms or data requests needed for controlling ingress or egress will be communicated immediately to the central processor. If a local processor fails to respond to an interrogation, the EECS shall annunciate a local processor off-line alarm.
1. Terminal Device Status: The local processor shall provide basic diagnostic of terminal devices and upon command shall communicate the status of the terminal devices to the system operator.
- H. Processors: The EECS shall consist of 1 central processor configured as a single master processor.

2.03 SYSTEM HARDWARE

The system shall include all equipment, cabling, connectors, adapters, terminators, and appurtenances as needed for a complete and operational EECS. Equipment located in the Security Center shall be rack mounted.

- A. Central Processor: The central processor shall be a digital computer based system and shall include the central processor unit and all a hardware, graphic controllers, input/output (I/O) controllers, control circuitry, random access memory, real-time clock/calendar, software, and firmware as required to provide a fully functional processor. All components shall be housed within a single enclosure. Central processor operating speed and random access memory configuration shall be needed to meet the response time as specified in paragraph SYSTEM RESPONSE. The central processor shall also incorporate an interface port to communicate with the system printer. The disk operating system programs, software and firmware, shall be furnished as an integral part of the processor assembly. The central processor shall not include any hardware precluding the purchase of a standard maintenance and service contract from the computer manufacturer.
1. Diagnostics: The central processor shall incorporate built-in diagnostic implemented in software/firmware, hardware or both. Each time the central processor is started or rebooted, it shall automatically execute a series of built-in tests and report equipment malfunctions, configuration errors, and inaccuracies on the system monitor screen and on the system printer. The EECS shall annunciate an audible alarm if the central processor fails the built-in diagnostics.
 2. Real-Time Clock/Calendar: The system real-time clock/calendar shall be continuously updated with battery backup sufficient to operate for not less than 1 year without external power input. Accuracy shall be within ½ second per day. The real-time clock/calendar shall maintain time in a 24 hour format including seconds, minutes, hours, date and month. The real-time clock/calendar shall be reset able by the operator, and shall update the clock/calendar in the local processor at

- least once every 24 hours. The real time clock shall have at least one EIA-232 output port to provide time data in ASCII format to other equipment in the console.
3. Long Term Data Storage: The central processor shall include long term storage media. The central processor shall have a fixed hard disk with at least 40 milliseconds or less. A 1.2 mega 5 ¼ inch floppy disk drive or 1.44 megabyte 3.5 disk drive shall be provided. The central processor shall also include a write once read many drive for system back-ups and archives.
- B. Map/Graphic Display: A dedicated map or graphic alarm display shall be provided showing the protected facilities. Zones corresponding to the portals monitored by the system shall be highlighted on the display. The status of each zone shall be emitting diodes (LEDs) to annunciate status, and LED test switch shall be provided.
1. FLASHING RED shall be used to annunciate an alarm.
 2. RED shall be used to alert the operator to an alarm and that the alarm has been acknowledged.
 3. YELLOW shall be used to advise the operator that a zone is under operator controlled access or that an alarm is being shunted.
 4. GREEN shall be used to indicate that the zone is secure and all equipment is functioning correctly.
- C. Local Processor: The local processor shall be a microprocessor controlled solid state electronic device. The local processor shall include a real-time clock/calendar that shall be updated at least once every 24 hours by the central processor. The local processor shall monitor portal status and associated terminal device status, and shall communicate the portal or terminal device status to the central processor. The local processor shall be able to support paired card readers on a single portal for anti-passback functions. The local processor shall provide electronic strike or other facility interface device release that is time adjustable from 1 to 30 seconds. The local processor shall be housed in a tamper-alarmed enclosure.
1. Local Processor and Enclosure Size and Weight: The local processor and its tamper-protected enclosure shall not exceed 20 inches in height by 20 inches in width by 8 inches in depth and shall not weigh more than 75 pounds.
 2. Local Alarm Annunciation: The local processor shall provide local audible alarm annunciation for itself and its associated portal/zones and terminal devices. The local alarm annunciation feature shall be enabled and disabled from the central processor under operator control.
 3. Communications Protocol: The communications protocol shall be compatible between the local processor, its associated EECS terminal devices, and the central processor.
 4. Terminal and Facility Interface Device Support: The local processor shall interface to the full range of EECS terminal and facility interface devices as shown.
 5. Response Times: The local processor shall initiate a response to a central processor interrogation within 100 milliseconds. The local processor shall respond to valid ingress and egress requests from its associated EECS terminal devices by generating a signal to the appropriate electric strike or other type of facility interface device within 100 milliseconds after identifier verification.
 6. Autonomous Local Control: In the event of a communication loss, the local processor shall automatically convert to autonomous local control and monitoring of its associated EECS terminal devices or facility interface devices. The local processor shall automatically revert to central control upon restoration of communications. System transactions occurring during the communications outage shall be recorded and retained in local processor memory and reported to the central database files upon restoration of communications. The local processor shall begin the report to the central database within 10 seconds after communications have been restored.
 7. Local Processor Capacities: The local processor shall be able to control a combination of at least 4 electric door strikes, card reader, keypads, or other EECS terminal devices and facility interface device. The local processor shall be able to store a subset of the EECS reference file database sufficient to support the enrollees needing access through each portal controlled by the local processor, and including personal, access authorization, and identifier data for each enrollee as needed to support ingress/egress requests. The local processor shall provide a local transaction history file with capacity to store at least the number of transactions calculated for each portal controlled by the local processor for 1000 transactions without losing any data.

8. Diagnostic: The local processor shall incorporate built-in diagnostic implemented in software/firmware, hardware or both. Each time the local processor is started it shall automatically execute a series of built-in tests, and report equipment malfunctions, configuration errors, and inaccuracies to the central processor and on the system printer. The EECS shall annunciate a fail-safe alarm if the local processor fails the built-in diagnostics. Diagnostic aids shall be provided within the local processor to aid in system setup, maintenance, and troubleshooting.
- D. Access Modes: Local processors shall be designed to allow any combination of terminal devices in any configuration as an access mode. The access modes shall be enabled and disabled for individual portals under the control of the system operator. A remote access mode shall be provided in which ingress/egress requests shall only be granted by an operator from the central console.
- E. Printer: A separate printer shall be provided for the alarm and report functions, and enrollment. The printer shall have a minimum 96 character standard ASCII character set based on ANSI X3.64 and ANSI X4.14. The printer shall have adjustable sprockets for paper width up to 15 inches and shall print at least 132 columns per line. The printer shall have a minimum speed of 150 characters per second. The minimum character spacing shall be at least 12 characters per inch and at least 3 lines per inch. The printer shall use standard size (8 ½ X 11 in.), sprocket fed fan fold paper, and have multiple copy capability. The unit shall have programmable control of top-of-form and variable line provided for the printer. Seven thousand sheets of printer paper and 24 ribbons shall be furnished after successful completion of the endurance test for the printer.
 1. Front Panel Controls: The printer shall include a front panel with controls and selectors for font election, initiation of a form feed, initiation of a line feed, and online/offline selection as a minimum. The front panel shall also include and LED or other type of visual indicator to display online/offline and font selection status.
- F. Color Graphic CRT Display: The color graphic display shall consist of a microprocessor-based color CRT with a minimum diagonal measurement of 12 inches and able to display at least eight colors. The unit shall have refresh memory with a screen refresh rate of at least 60 times per second, non interlaced. The CRT shall have a minimum screen display of 1920 characters (24 lines with 80 characters each). The screen display shall have a minimum resolution of 640 by 350 pixels.
- G. Keyboard: Keyboards shall be furnished for use with the monitor. As a minimum, the keyboard shall include a 96-character standard ASCII character set based on ANSI X4.14. The keyboard shall provide the man/machine interface to allow the operator to interact with EECS command and application software.
- H. Enhancement Hardware: Enhancement hardware such as special function keyboards, light pens, touch screen devices, or mouse shall be provided if they are required to opt the system.
- I. System Maintenance Hardware: Hardware recommended by the system manufacturer for performing system maintenance shall be provided.

2.04 SOFTWARE

Software shall be categorized as system software and application software. System software shall consist of software to support system setup, system operation, routine hard drive backups, and other maintenance routines. Application software shall consist of software to provide complete operation of EECS. The contractor shall provide software in modules to meet the requirements of the system to be installed at the site.

- A. User-Alteration: The design of processor assemblies shall preclude user-alteration of the integral firmware and shall preclude use of the processor assemblies for purposes other than the intended system, portal, and zone status monitoring, control, annunciation, and display.
- B. System Software: System software including the operating system shall be completely off-the-shelf, modifiable for the site specific needs of the EECS. The system software shall be compatible with all system hardware and application software. System software shall support the application programs. Each program shall be assigned a priority level. The priority levels shall be sufficient in number of provide total functional operation as specified. The stand system software supplied shall not be modified in any way that would preclude the purchase of a standard maintenance and service contract form the computer manufacturer.
 - 1. Initialization Program: The software shall include an initialization program adequate to automatically initialize EECS operation when security console equipment is powered up. The initialization program shall also load the central processor memory form the fixed hard disk system.
 - 2. Disk Operating System: A currently available and supported disk operating system shall be utilized, including:
 - a. Program control functions including programs loading, execution, and termination
 - b. Error Detection and recovery.
 - c. Devices drivers shall be supplied as needed for operation of the keyboard, CRT, printer, disk systems, and enhancement hardware.
 - d. File management including creation and deletion of files, searching, sequential and random file access, and maintenance of a file directory and sub directories.
 - e. Disk management including drive selection, partitioning space allocation and recovery, write verification, and a copy routine to transfer information between any two devices.
 - f. Diagnostic programs to check the status of the Operator's Console on its screen.
 - g. Maintain current date and time.
 - 3. Disk Compress Software: Utility software shall be provided to recover file space lost to fragmentation by manage files on the fixed hard disk as contiguous as possible.
- C. Application Software: Application software shall be comprised of computer programs and computer databases as required. Application software shall be menu driven or command driven. The software programs provided shall not require modification to monitor and control the number of output relays and zones specified or shown. The manufacturer shall upgrade, update, revise, or otherwise modify software and firmware as required to incorporate manufacturer-developed improvements or firmware portions system for a period of one year after installation.
 - 1. Password Control: Any action that could compromise the security or integrity of the EECS shall be password controlled. A minimum of 3 password levels shall be provided.
 - 2. Data Entry: Installation-related characteristics shall be user-entered by keyboard control operations prompted by display instruction for the operator. Entry of installation-related data shall not require specific computer training or knowledge of computer operator, computer languages, or programming procedures. Data entry shall neither require not permit processor assembly or microprocessor programming or modification of the integral firmware.
 - 3. Input Error Recovery: The system shall supervise operator inputs to ensue they are correct for proper execution. Operation assistance shall be provided whenever a command cannot be executed. Error responses shall not require an operator to look up a code in a manual or other hard copy document. Conditions of which operator error assistance messages shall be generated include but shall not be limited to:
 - a. The command used is incorrect or incomplete.
 - b. The operator is restricted form using that command.
 - c. The command addresses a point that is disabled or out of service.
 - d. The command would violate constraints.

2.05 ELECTRONIC ENTRY CONTROL SYSTEM ALARMS

The EECS shall annunciate an alarm when the following conditions occur. All alarms shall be annunciated at the security console both audibly and visually. An alarm report shall also be printed on the system printer. The alarm annunciation shall continue until acknowledged by the system operator. Only one control key shall be needed to acknowledge on alarm. The EECS shall control, monitor, differentiate, rank, annunciate, and allow operators to acknowledge, in real time, alarm signals generated by EECS equipment. The EECS shall also provide a means to define and customize the annunciation of each alarm type. The EECS shall use audio and visual information to differentiate the various types of alarms. Each alarm type shall be assigned an audio and a unique visual identifier.

- A. Local Processor Failure: The EECS shall continuously supervise local processor bus lines by monitoring the presence of communications with local processors and shall annunciate an alarm if communications failure is detected.
- B. Software Tamper: The EECS shall annunciate a tamper alarm when unauthorized changes to the EECS database files are attempted. Three consecutive unsuccessful attempts to log onto an EECS central processor shall generate a software tamper alarm. A software tamper alarm shall also be generated when an operator or other individual makes 3 consecutive unsuccessful attempts to invoke central processor functions beyond their authorization level. The EECS application software shall maintain a transcript file of the last 5000 commands entered at each central processor to serve as an audit trail. The EECS shall not allow write access to the system transcript files by any person, regardless of their authorization level. The EECS shall only allow acknowledgment of software tamper alarms and read access to the EECS transcript files by operators and managers with the highest password authorization level available in the system.
- C. Access Denial: The EECS shall annunciate an alarm when an attempt has been made to pass through a controlled portal and access has been denied.
- D. Portal Open: The EECS shall annunciate an alarm when an access controlled portal has been open longer than a predefined time delay. The time delay shall be adjustable, under operator control, over a range of at least from 1 second to 1 minute with a maximum resolution of 1 second.
- E. Bolt Not Engaged: The EECS shall annunciate an alarm when the bolt at an access controlled portal has been open longer than a predefined time delay and generate an access control alarm. The time delay shall be adjustable, under operator control, over a range of at least from 1 second to 1 minute with a maximum resolution of 1 second.
- F. Strike Not Secured: The EECS shall annunciate an alarm when the strike at an access controlled portal has been left unsecured longer than a predefined time delay and generate an access control alarm. The time of delay shall be adjustable, under operator control, over a range of at least from 1 second to 1 minute with a maximum resolution of 1 second.
- G. Intrusion Alarm: The EECS shall annunciate alarms based on sensor or tamper alarm. Intrusion alarms shall generate a single unique signal indicative of this alarm type.
- H. User Defined Prompts/Messages linked to Alarms: The EECS shall provide a means to relate operator defined prompts and other messages to predefined alarms. Whenever one of the predefined alarms is annunciated on an EECS control terminal, the prompt or messages related to the alarm shall be automatically displayed.
- I. Alarm Shunting/System Bypass: The EECS shall provide a means to ignore operator selected alarm types at operator selected portals in order to allow standard access control procedures to be bypassed (shunted). Predefined shunting shall only be available to system operators with the proper password. With the system on-line, the operators shall be able to select at least 16 alarms and 16 portals to be

shunted. The EECS shall also provide for predefined alarm shunting based upon time zones. This capability shall only apply to the access control alarm type.

- J. System Self Test: The design of the EECS computer equipment shall provide for continuous internal programs and data memory self test.

2.06 FIELD HARDWARE

- A. Card Readers and Credential Cards: EECS card readers shall use unique coded data stored in or on a compatible credential card as an identifier. The card readers shall be proximity type, and shall incorporate built-heaters or other cold weather equipment to extend the operating temperature range as needed for operation at the site.

Communications protocol shall be compatible with the local processor. The contractor shall furnish card readers to read magnetic stripe credential cards, and the matching credential cards. The cards shall contain coded data arranged as a unique identification code stored on or within the card, and of the type readable by the EECS card readers. The Contractor shall include within the card's encoded data a non duplicated unique facility identification code common to all EECS credential cards provided. Enrollment equipment to support local encoding of badges including cryptographic and other internal security checks shall be supplied. Cards, card readers, and enrollment equipment shall be compatible.

1. Magnetic Stripe: Magnetic stripe card readers shall read credential cards that meet the requirements of the ANSI X4.13 and ANSI X4.16. Magnetic stripe credential cards shall use single layer 4000 Oersted magnetic tape material. The magnetic tape material shall be coated with Teflon and affixed to the back of the credential card near the top. The number of bits per inch, number of tracks, and number of unique codes available for the magnetic tape shall be in accordance with ANSI X4.16.
2. Card Reader Display: The card readers shall include an LED or other visual indicator display. The display shall indicate power on/off, and whether user ingress and egress requests have been accepted or rejected.
3. Card Reader Response Time: The card reader shall respond to ingress and egress requests by generating a signal to the local processor. The response time shall be 800 milliseconds or less from the time the card reader finishes reading the credential card until a response signal is generated.
4. Card Reader Size and Weight: The card reader shall not be more than 10 inches high by 10 inches wide by 5 inches deep. The card reader shall not weight more than 15 pounds.
5. Card Reader Power: The card reader shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
6. Card Reader Mounting Method: Card readers shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
7. Credential Card Modification: EECS cards shall be able to be modified by lamination during the enrollment process for use as a picture and identification bade as needed of the site without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip of affixing the credential card to the type badge holder used at the site.
8. Card Size and Dimensional Stability: Credential cards shall be 2 1/8 inches by 3 3/8 inches. The credential card material shall be dimensionally stable in the sense that an undamaged card with deformations resulting form normal use shall be readable by the card reader.
9. Card Materials and Physical Characteristics: The credential card shall be abrasion resistant, non flammable, and resent no toxic hazard to humans when used in accordance with manufacturer's instructions. The credential card shall be impervious to solar radiation and other effects of ultraviolet light.
10. Card Construction: The credential card shall be of core and laminate or monolithic construction. Lettering logos and other markings shall be hot stamped into the credential material. The credential card shall incorporate phosphorous ink as security enhancement.

11. Card Durability and Maintainability: The credential cards shall be designed and constructed to yield a useful lifetime of at least 5000 insertions or swipes or 5 years whichever results in a longer period of time. The credential card shall be able to be cleaned through wiping the credential card with a sponge or cloth wetted with a soap and water solution.
- B. Keypads: EECS keypads shall use unique combination of alphanumeric and other symbols as an identifier. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Communications protocol shall be compatible with the local processor.
1. Keypad Display: Keypads shall include an LED or other type of visual indicator display and provide visual status indications and user prompts. The display shall indicate power on/off, and whether user ingress and egress requests have been accepted or rejected. The design of the keypad display or keypad enclosure shall limit the maximum horizontal and vertical viewing angles of the keypad. The maximum horizontal viewing angle shall be plus and minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical angle shall be plus and minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
 2. Keypad Response Time: The keypad shall respond to ingress and egress requests by generating a signal to the local processor. The response time shall be 800 millisecond or less from the time the last alphanumeric symbol is entered until a response signal is generated.
 3. Size and Weight: The keypad shall not be more than 10 inches high by 10 inches wide by 5 inches deep. The keypad shall not weight more than 10 pounds.
 4. Keypad Power: The keypad shall be powered from the source as shown and shall not dissipate more than 150 watts.
 5. Keypad Mounting Method: Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
 6. Keypad Duress Codes: Keypads shall provide a means for users to indicate a duress situation by entering a special code. Upon receipt of the special duress code, the EECS shall announce a duress alarm.
- C. Enrollment Center Equipment: The contractor shall provide enrollment equipment to enroll personnel into and disenroll personnel from the EECS database. The enrollment equipment shall only be accessible to authorized EECS enrollment personnel. The contractor shall provide enough credential cards for all personnel to be enrolled at the site plus an additional 50 percent for future use. The enrollment equipment shall include subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with central processor(s).
- D. Security Console Accessories: Equipment racks shall be as specified in EIA 310. All equipment, with the exception of the printers, shall be rack mounted in the console and equipment racks. The console and equipment racks and cabinets shall be color coordinated. A locking cabinet approximately 6 feet high, 3 feet wide, and 2 feet deep with three adjustable shelves, printer paper, ribbons, manuals, and other documentation shall be provided.

2.07 DATA COMMUNICATIONS

- A. Data Transmission Media: DTM shall be provided as required by manufacturer. Wire line DTM circuits shall not be used to power the local processors. Interrogation and response communications between the EECS and local processor shall use one circuit for interrogation and one circuit for response and may have one or more parallel branches.
- B. Error Detection and Retransmission: A cyclical redundancy code or equivalent error detection scheme shall be used with communications between the local processor and the central processor which shall detect all single and double bit errors, all burst errors of eight bits or less, and at least 99 percent of all other multi-bit and burst error conditions. Interactive or product error detection coded alone shall not be acceptable. A message shall be declared in error if a single bit is received incorrectly. The system

shall retransmit all messages that were transmitted with errors. A two digit decimal number shall be operator assignable to each DTM circuit representing the number of retransmission attempts. When the number of consecutive retransmission attempts equals the assigned quantity, the central processor shall annunciate as communications failure alarm. The system shall monitor the frequency of data transmission error for displays and logging.

2.08 WIRE AND CABLE

- A. General: The Contractor shall provide all wire and cable not indicated as GFE. All wiring shall meet NEC and NFPA 70 standards.
- B. Terminal Device Wiring: Terminal device wiring shall be shielded as needed to match hardware. Multiconductor wire shall be at least 20 AWG and shall have an outer jacket of PVC.
- C. Class 2 Low Energy Conductors: The conductor sizes specified for digital functions shall take precedence over any requirements for Class 2 low energy signal-circuit conductors specified elsewhere.

PART III - EXECUTION

3.01 GENERAL

The Contractor shall install all system components, including Government furnished equipment, and apputences, in accordance with the manufacturer's instructions, ANSI-C2 and as shown, and shall furnish all necessary interconnections, services, and adjustments required for a complete and operable system as specified and shown. Control signal, communications, and data transmission line grounding shall be installed as necessary to preclude ground loops, noise, and surges form adversely affecting system operation.

- A. Installation Standards: The Contractor shall install the EECS in accordance with the standards for safety, NFPA 70, UL 681, UL 1037 and UL 1076, and the appropriate installation manual for each equipment type. Components within the system shall be configured with appropriate service points to pinpoint system trouble in less than 20 minutes.
- B. Installation: All wiring, including low voltage wiring outside the security control console, cabinets, boxes, and similar enclosures, shall be installed in rigid galvanized steel conduit conforming to UL 6. Minimum size on conduit shall be ½ inch. Connections shall be tight tapered threaded. No thread less fittings or couplings shall be used. Conduit outlet boxes, pull boxes, junction boxes, conduit fittings and similar enclosures shall be cast metal or malleable iron confirming to Fed. Specification. W-C-586, with threaded hubs or bodies. Electric metallic tubing (EMT), armored cable, nonmetallic sheathed cable or flexible conduit will not be permitted except where specifically shown. DTM shall not be pulled into conduits or place in raceways, compartments, outlet boxes, junction boxes, or similar fittings with other building wiring. Flexible cords or cord connections shall not be used to supply power to any components of the intrusion detection system, except where specifically noted herein. All other electrical work shall be specified and as shown. Grounding shall be installed as necessary to preclude ground loops, noise, and surges form adversely affecting system operation.
- C. Enclosure Penetrations: All exterior enclosure penetrations shall be form the bottom unless the system design requires penetration form other directions. Penetrations of interior enclosures involving transitions of conduit form interior to exterior, and all penetrations on exterior enclosures shall be sealed wit rubber silicone sealant to preclude the entry of water.

- D. Software Installation: The Contractor shall load all software as specified and required for and operational EECS, including databases and all specified programs. Upon successful completion of the endurance test, the Contractor shall provide original and backup copies on floppy disk of all accepted software including diagnostics.
- E. System Startup: The Contractor shall not apply power to the EECS until after:
1. EECS equipment items and DTM have been set up in accordance with manufacturer's instructions.
 2. A visual inspection of the EECS has been conducted to insure that defective equipment items have not been installed and that there are not loose connections.
 3. System wiring have been tested and verified as correctly connected as indicated.
 4. All system grounding and transient protection systems have been verified as properly installed and connected as indicated.
 5. Power supplies to be connected to the EECS have been verified as the correct voltage, phasing, and frequency as indicated.
 6. Satisfaction of the above requirements shall not relieve the Contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as a result of Contractor work/equipment.

3.02 MAINTENANCE AND SERVICE

- A. General requirements: The Contractor shall provide a separate cost to all services required and equipment necessary to maintain the entire (EECS) in an operational state as specified for a period of 1 year after formal written acceptance of the system, and shall provide all necessary material required for performing scheduled adjustments or other nonscheduled work.
- B. Description of Work: The adjustment and repair of the EECS includes computer equipment, software updates, signal transmission, equipment, access control, facility interface, and support equipment. Responsibility shall be limited to Contractor installed equipment. Provide the manufacturer's required adjustments and other work as necessary.
- C. Personnel: Service personnel shall be qualified to accomplish all work promptly and satisfactorily. The Owner shall be advised in writing of the name of the designated service representative, and of any change in personnel.
- D. Schedule of Work: The Contractor shall perform two inspections at 6 month intervals or more often if required by the manufacturers. The inspections shall include:
1. Visual checks and operational tests of the central processors, local processors, monitors, keyboards, system printers, peripheral equipment, facility interface/actuator devices, EECS equipment, EECS equipment indicators, and electrical and mechanical controls.
 2. Clean system equipment, including interior and exterior surfaces.
 3. Perform diagnostics on all equipment
 4. Check and calibrate each EECS device.
 5. Check, test and calibrate personnel identify problems.
 6. Run system software and correct diagnostic problems.
 7. Resolve previous outstanding problems.
- E. Scheduled Work: All scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.
- F. Emergency Service: The Owner will initiate service calls when the EECS is not functioning properly. Qualified personnel shall be available to provide service to the complete EECS. The Owner shall be furnished with a telephone number where the serve supervisor can be reached at all times. Service

personnel shall be at the site within 8 hours after receiving a request for service. The EECS shall be restored to proper operating condition within 3 calendar days after receiving a request for service

- G. Operation: Performance of scheduled adjustments and repair shall include verification of operation of the EECS as demonstrated by the applicable tests of the performance verification test.
- H. Records and Logs: The Contractor shall keep records and logs of each task, and shall organize cumulative records for each major component and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain calibration, repair, and programming data. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the EECS.
- I. Work Requests: The Contractor shall separately record each service call request, as received. The form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what have to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. The Contractor shall deliver a record of the work performed within 5 days after work is accomplished.
- J. System modifications: The Contractor shall make recommendations for system modifications in writing to the Owner. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Owner. Modifications made to the systems shall be incorporated into the operations and maintenance manuals, and other documentation affected.
- K. Software: The Contractor shall provide software updates and verify operation in the systems required. These updates shall be accomplished in a timely manner, fully coordinated with the EECS operators, and shall be incorporated in the operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the Contractor shall install and validate the latest released version of the manufacture's software.

END OF SECTION 16752

PART I - GENERAL1.01 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

- A. ANSI S3.2 (1960; R 1982) Method for Measurement of Monosyllabic Word Intelligibility.
- B. EIA 310-C (Nov. 1977; R 1982) Racks, Panels and Associated Equipment.
- C. NFPA 70 (1987; Errata; Int. Am. 87-1 thru Int. Am. 87-6) National Electrical Code

1.02 SYSTEM DESCRIPTION

- A. The radio and public address system shall consist of an audio distribution network to include amplifiers, mixers, microphones, speaker, cabling, and any ancillary components required to meet the required system configuration and operations.

1.03 SYSTEM PERFORMANCE

- A. The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1-octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3 -octave bands of pink noise at locations across the designated area selected by the Architect/Engineer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) to any location in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Paschal (0.00002 Newtons per square meter).

1.04 SUBMITTALS

- A. The following shall be submitted in accordance with Section 01300 "SUBMITTALS":
 - 1. Shop Drawings: Shop drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams and coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearance of maintenance and operation.
 - 2. Quality Assurance Plan: Quality assurance test plan and test procedures shall be submitted for the acceptance tests for approval. The test plan and test procedures shall explain in detail, step-by-step, actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance.
 - 3. Test Reports: Upon completion and testing of the installed system, test reports shall be submitted in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria. Each test report shall indicate the final position of controls and operating mode of the system, the manufacturer, model number, and serial number of test equipment used in each test.
 - 4. Operations and Maintenance Manuals: The Contractor shall furnish six complete copies of operating instructions outlining the step-by-step procedure required for system startup, operation, and shutdown. The instructions shall include equipment layout and schematics of simplified wiring and control diagrams of the system as installed. The instructions shall include the manufacturer's name, model number, and brief description of all equipment and their basic

operating features. The operating instructions shall be submitted an approved prior to the training course.

- B. Spare Parts Data: After approval of the detail drawings, and not later than 1 month prior to the date of beneficial occupancy, the Contractor shall furnish spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

1.05 DELIVERY AND STORAGE

- A. Equipment placed in storage until installation time shall be stored with protection form the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.06 VERIFICATION OF DIMENSIONS

- A. The Contractor shall become familiar with the details of the work and working conditions, shall verify dimensions in the field, and shall advise the Architect/Engineer of any discrepancies before performing the work.

PART II - PRODUCTS

2.01 STANDARD PRODUCTS

- A. Materials and Equipment to be provided shall be the standard products, and shall essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified. Equipment shall be supported by a service organization that is, in the opinion of the Architect/Engineer, reasonably convenient to the site.
1. Identical Items: Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.
 2. Nameplates: Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.02 POWER AMPLIFIERS

- A. Power amplifiers as a minimum conform to the following specifications:

1. Rated power output: 100 Watts
2. Frequency Response: + / - 2 dB, 60-13,000 Hz
3. Distortion: Less than 2 percent at RPO, 600-13,000 Hz
4. Input Impedance: 50 k ohm unbalanced
5. Output Impedance: 83.3, 10.4, 8.0 and 4.0 ohms
6. Output Voltage: 70.7, 25, 22, and 15.5 volts
7. Power Requirements: 110-125 Vac 60 Hz

2.03 MICROPHONE INPUT EXPANDER

- A. Microphone input expander shall as a minimum conform to the following specifications:

1. Rated power output: .25 volts into 10,000 ohms
1.0 volts into 10,000 ohms
2. Frequency Response: + / - 2 dB, 20 -20,000 Hz
3. Distortion: Less than 2 percent at RPO, 20 -20,000 Hz
4. Input: 4 transformer - coupled balanced 150 ohm

5. Input Sensitivity: 0.003 volts
6. Input Channel Isolation: 70 dB minimum
7. Power Requirements: 28 Vac

2.04 LOUDSPEAKERS

A. Cone Speakers: The cone speaker as a minimum conforms to the following specifications:

1. Application: Ceiling
2. Frequency range: 60 to 12,000 Hz
3. Power Rating: Normal - 7 watts
Peak - 10 watts
4. Voice Coil Impedance: 8 ohms
5. Line Matching Transformer Type: 25/70 volt line
6. Capacity: 2 watts
7. Primary Taps: 0.5, 1, 2 watts
8. Primary Impedance: 25 volts - 1250, 625, and 312 ohms
70 volts - 10k, 5k, and 2.5 ohms
9. Frequency Response: 30 -20,000 Hz
10. Insertion Loss: Less than 1 dB

B. Speaker Enclosures: Wall baffle or column speaker enclosures shall be of the tuned-port design for precise balancing and tuning of the speaker. The enclosures shall be constructed throughout of ¾ inch, high density board, with screwed and glued joints, durably braced, and padded with fiberglass where acoustically required. For wall mounting applications, the wall baffle enclosure shall come equipped with a wall-mounting bracket designed to assure a rigid mounting to any flat surfaces. Column speaker enclosures shall have a 25 degree vertical dispersion and 90 degree horizontal dispersion. The effective length of throw shall be a minimum of 50 feet.

2.05 EQUIPMENT RACKS

A. Equipment shall be mounted on 19 inch racks in accordance with EIA 310-C and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided. Perforations or louvers may be provided in front panels to ensure adequate ventilation of equipment. Racks and panels shall be factory finished with uniform baked enamel over rust inhibiting primer.

2.06 SPEAKER AND MICROPHONE CABLE

A. Cables shall be of the gauge required depending upon the cable run length. In no case shall any cable be used which is smaller than 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 1/32 inch thick. Cables shall be shielded with a 34 gauge tinned soft copper strand formed into a braid. Cables shall be jacketed with a Fluoropolymer compound. The jacket thickness shall be 0.0200 inch minimum.

2.07 POWER SURGE PROTECTION

A. Major components of the system such as power amplifiers, mixer-preamplifiers, phonographs, and tuners, shall have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources.

2.08 SIGNAL SURGE PROTECTION

A. Major components of the system shall have internal protection circuits that protects the component from mismatched loads, direct current, and shorted output lines.

PART III - EXECUTION3.01 INSTALLATION

- A. All equipment shall be installed as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions shall be weatherproofed.
1. Equipment Racks: Racks shall be mounted side-by-side and bolted together. Items of the same function shall be grouped together, either vertically or side-by-side. Controls shall be symmetrically arranged at a height as shown. Audio input and interconnections shall be made with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.
 2. Wiring: Wiring shall be installed in cable trays, or electric metallic tubing as indicated on the drawings. Wiring for microphone, grounding line level, video, speaker, and power cables shall be isolated from each other by physical isolation and metallic shielding. Shielding shall be terminated at only one end.

3.02 GROUNDING

- A. All grounding practices shall comply with NFPA 70. The antenna mast shall be separately grounded. The system shall utilize a multiple-point signal grounding scheme where conductive path connections are required between each piece of equipment and the reference ground point. An isolated ground bar for power shall be provided for the connection of the main service ground utilizing a No. 6 conductor.

3.03 ACCEPTANCE TESTS

- A. After installation has been completed, the Contractor shall conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. The Contractor shall notify the Architect/Engineer fourteen days prior to the performance of tests. In no case shall notice be given until after the Contractor has received written Contracting Officer's approval of the test plans as specified. The acceptance tests shall include originating and receiving messages at specified stations, at proper volume levels, without cross talk or noise from other links or non-designated units. Test shall utilize the phonetically balanced monosyllabic word intelligibility test in accordance with ANSI S3.2. In order to be acceptable, a score of at least 75 percent must be obtained for each system tested.

3.04 TRAINING

- A. The Contractor shall conduct a training course for five members of the operating and maintenance staff as designated by the Architect/Engineer. The training course will be given at the installation during normal working hours for a total of 4 hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations. The Architect/Engineer shall be notified at least 14 days prior to the start of the training course.

END OF SECTION 16770

PART I - GENERAL1.01 WORK INCLUDED

- A. Design and installation of liquid detection and alarm system.

1.02 RELATED WORK

Not Used

1.03 REFERENCES

- A. Factory Mutual Standards
- B. Underwriters Laboratories Listings and Standards

1.04 SYSTEM DESCRIPTION

- A. System to provide coverage for mechanical pipe trench area to provide liquid detection capability.
- B. Interface system with building monitoring and control system.
- C. Provide system in accordance with manufacturer's written requirements and guidelines.
- D. Furnish a complete cable-type leak detection and location system consisting of a microprocessor based monitoring unit, sensor cable, probes, system layout map and auxiliary equipment required to provide continuous monitoring of the sensing string(s) for leaks, shorts, breaks and probe activation. If any of these conditions should occur at any point along the cable, an alarm shall sound, type of condition shall be clearly identified and the location clearly displayed. The system shall be designed to monitor the mechanical pipe trench area and shall detect all liquids which may be present using a single sensor cable.

1.05 QUALITY ASSURANCE

- A. Equipment and Components: Bear UL and FM label or marking.
- B. Specialist Firm: Company specializing in systems with three years experience.

1.06 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 01300.

1.07 PROJECT RECORD DOCUMENTS

- A. Submit documents under provisions of Section 01700.

1.08 OPERATION AND MAINTENANCE MANUAL

- A. Submit manufacturer's operation and maintenance data under provisions of Section 01700.
- B. Include written maintenance data on components of system, servicing requirements, and Record Drawings.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers of the cable-type liquid detection system are:

1. Liebert
2. Light Engineering Displays, Inc.
3. Raychem Tracetek
4. Fenwal
5. PermAlert

2.02 PERFORMANCE

- A. The Leak Detection System shall identify the presence of a liquid at any point along its sensing string and indicate its location within $\pm 1\%$ of the distance from the last calibration point or ± 5 feet, whichever is greater.
- B. The system shall be capable of monitoring up to 1,500 feet of cable per sensor string from a single monitoring unit.
- C. The system shall be capable of monitoring (detecting and locating) for multiple leaks or additional liquid on the sensor cable.
- D. The system shall be capable of identifying the location of breaks and shorts on the cable. When either of these faults occurs, an alarm shall sound and a display visible on the front of the monitoring unit shall clearly indicate the type of fault, i.e. BREAK or SHORT and display the location of the fault. A Tektronix TDR 1503C or equal shall be furnished to the owner if the continuous monitoring panel cannot locate breaks and shorts.
- E. The monitoring unit shall have a green LED on the front panel to indicate the unit is powered. A two line by forty-character backlit LCD shall be visible from the front of the unit to provide system data. A red LED on the front panel shall indicate an alarm condition has occurred.
- F. The monitoring unit power requirements shall be 120/240 VAC, 100 VA, 50/60 Hz, single phase. Monitoring units shall be equipped with either an RS-232, RS-485 communication port or a 4-20 MA output and a minimum of one common and one per cable SPDT output relay, rated for 250 VAC, 10 amp.
- G. The monitoring unit shall be enclosed in a modified NEMA 12 enclosure. The unit shall be UL listed and FM approved to provide connections for intrinsically safe sensor circuits for use in Class 1, Division I, Groups C & D Hazardous Locations. Ability to locate a leak shall not depend on battery backed up functions. In the event of power failure, system conditions and parameters shall be stored in nonvolatile memory allowing the unit to automatically resume monitoring, without resetting, upon restoration of power. An on-off switch shall be provided in the panel for servicing.
- H. The sensor cables shall be suitable for use with the monitoring unit. The sensor cables shall be of coaxial construction consisting of an insulated copper center conductor, a suitable spacer material, and an outer braid.
- I. All conductors must not be less than twenty (20) AWG for mechanical strength.

- J. All cables must be capable of field installation of connectors by trained technicians. The cable shall be available in lengths up to 1,500 feet in bulk spools. All cables must be field repairable by trained technicians. Cable on flat surfaces shall have hold down clips every 8 feet and cable tags every 50 feet.

PART III - EXECUTION

3.01 PREPARATION

- A. The system shall be installed per the manufacturer's recommended installation procedures. All local, state and federal codes and requirements shall be followed. The system shall be installed by properly trained personnel.

3.02 GRAPHIC LOCATOR MAP

- A. A location map shall be provided with the system by the installing contractor indicating the "As Installed" system configuration and sensing string layout. Footage along the cable shall be provided as references to locate leaks. Footage shall be based upon Calibration Points taken per Section 3.03.

3.03 CALIBRATION POINTS

- A. The installing contractor shall be responsible for taking and recording calibration points along the sensing string per the manufacturer's recommended procedures. All cable not in containment piping shall have cable tags every 50 feet.

3.04 TRAINING REQUIREMENTS

- A. Prior to final acceptance, the Contractor shall provide operation training to each shift of the Owner's personnel. Each training session shall include emergency procedures, system control panel operation, trouble procedures, and safety requirements. Each session shall include a complete demonstration of the system. Dates and times of the training period shall be coordinated through the Owner not less than two weeks prior to session.

3.05 OPERATION AND MAINTENANCE MANUALS

- A. Prior to final acceptance, the contractor shall provide complete operation and maintenance instruction manuals (three copies for each system) to the Owner. All aspects of system operation and maintenance shall be detailed, including electrical schematics of all circuits, a written description of the system design, drawings illustrating control logic and equipment location, and technical bulletins describing each piece of equipment used in the system. Checklist and procedures for emergency situations, troubleshooting techniques, and maintenance operations shall be included.

3.06 AS-BUILT DRAWINGS

- A. Upon completion of each system, the Contractor shall provide four copies of as-built drawings showing actual installation details. All equipment locations (alarms, control panels) shall be shown, as well as exact conduit and piping routing details and head location. One copy of reproducible engineering drawings will be provided reflecting all actual installation details.

3.07 ACCEPTANCE TESTS

- A. The contractor shall carry out the acceptance tests in the presence of the approving authority or its representative. The tests shall include check and adjustment of all detectors and an operational test of all control panels, alarms, and all operating parts of the system. If the tests are unsuccessful due to a contractor or equipment fault, the contractor shall provide the additional retest as necessary.

3.08 WARRANTY

- A. All system components furnished under this contract shall be guaranteed against defective design, materials and workmanship for the full warranty time which is standard with the manufacturer and/or supplier, but in no case less than one year from the date of system acceptance.

END OF SECTION 16805

PART I - GENERAL1.01 WORK INCLUDED

- A. Design and installation of liquid detection and alarm system.

1.02 RELATED WORK

- A. Not Used

1.03 REFERENCES

- A. Factory Mutual Standards
- B. Underwriters Laboratories Listings and Standards

1.04 SYSTEM DESCRIPTION

- A. System to provide coverage for Data Center area to provide spot-type liquid detection capability below access floor.
- B. Interface system with building monitoring and control system.
- C. Provide system in accordance with manufacturer's written requirements and guidelines.
- D. Furnish a complete spot-type leak detection and location system consisting of a micro process or based monitoring unit, sensors, cable, and auxiliary equipment required to provide monitoring of leaks and liquid conditions in monitored areas. If any of these conditions should occur, an alarm shall sound and the location clearly displayed. The system shall be designed to monitor the subfloor or below access floor of a computer room and shall detect all liquids which may be present.

1.05 QUALITY ASSURANCE

- A. Equipment and Components: Bear UL and FM label or marking.
- B. Specialist Firm: Company specializing in systems with three years experience.

1.06 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 01300.

1.07 PROJECT RECORD DOCUMENTS

- A. Submit documents under provisions of Section 01700.

1.08 OPERATION AND MAINTENANCE MANUAL

- A. Submit manufacturer's operation and maintenance data under provisions of Section 01700.
- B. Include written maintenance data on components of system, servicing requirements, and record drawings.

PART II - PRODUCTS2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers of the spot-type liquid detection system are:

1. Liebert
2. Light Engineering Products, Inc.
3. Or Approved equal.

PART III - EXECUTION3.01 PREPARATION

A. The system shall be installed per the manufacturer's recommended installation procedures. All local, state and federal codes and requirements shall be followed. The system shall be installed by properly trained personnel.

3.02 TRAINING REQUIREMENTS

A. Prior to final acceptance, the Contractor shall provide operation training to each shift of the Owner's personnel. Each training session shall include emergency procedures, system control panel operation, trouble procedures, and safety requirements. Each session shall include a complete demonstration of the system. Dates and times of the training period shall be coordinated through the Owner not less than two weeks prior to session.

3.03 OPERATION AND MAINTENANCE MANUAL

A. Prior to final acceptance, the contractor shall provide complete Operation and Maintenance Instruction Manuals (three copies for each system) to the Owner. All aspects of system operation and maintenance shall be detailed, including electrical schematics of all circuits, a written description of the system design, drawings illustration control logic and equipment location, and technical bulletins describing each piece of equipment used in the system. Checklist and procedures for emergency situations, troubleshooting techniques, and maintenance operations shall be included.

3.04 AS-BUILT DRAWINGS

A. Upon completion of each system, the Contractor shall provide four copies of as-built drawings showing actual installation details. All equipment locations (alarm, control panels) shall be shown, as well as exact conduit and piping routing details and head location. One copy of reproducible engineering drawings will be provided reflecting all actual installation details.

3.05 ACCEPTANCE TESTS

A. The contractor shall carry out the acceptance tests in the presence of the approving authority or its representative. The tests shall include check and adjustment of all detectors and an operational test of all control panels, alarms, and all operating parts of the system. If the tests are unsuccessful due to a contractor or equipment fault, the contractor shall provide the additional retest as necessary.

3.06 WARRANTY

A. All system components furnished under this contract shall be guaranteed against defective design, materials and workmanship for the full warranty time which is standard with the manufacturer and/or supplier, but in no case less than one year from the date of system acceptance.

END OF SECTION 16806

PART I - GENERAL1.01 SECTION INCLUDES

- A. Testing and jurisdictional approval of installed services.

1.02 RELATED SECTIONS

- A. Division 1: General Requirements
- B. Section 16000: Summary of Work
- C. Section 16010: General Requirements for Electrical Work
- D. Section 16050: Basic Materials and Methods
- E. Section 16110: Raceway System
- F. Section 16131: Pull and Junction Boxes
- G. Section 16134: Outlet Boxes

1.03 PROJECT RECORD DOCUMENTS

- A. Submit record documents under provisions of Section 01700.
- B. Accurately record actual locations of all underground and concealed conduit systems.

1.04 QUALITY ASSURANCE

- A. Conduit System approval shall be obtained in accordance with jurisdictional requirements to demonstrate underground and concealed systems acceptability.

1.05 SEQUENCING AND SCHEDULING

- A. Sequence and schedule work under the provisions of Section 01010 and Section 01011.
- B. Sequence testing and approval to allow phasing of work and completion of systems to meet Master Project Schedule constraints.

PART II - PRODUCTS

Not Used.

PART III - EXECUTION3.01 PREPARATION

- A. Provide instruments and devices required for testing and approval. Coordinate and provide for jurisdictional authority's requirements.

3.02 TEST PROCEDURE

- A. Install conduit in sequence to allow fast track construction. Obtain approval from jurisdictional authority on a daily basis for work installed to allow backfill to proceed expeditiously.
- B. During backfill and compaction, ensure that conduit system remains intact and that pull ropes are free and that no obstructions occur.
- C. Provide temporary cap and closure at all ends to prevent accumulation in conduit.

END OF SECTION 16991