# PHYSICS & ENGINEERING BUILDING’S ELECTRICAL RELIABILITY UPGRADES

## Project Specifications

Prepared for:

Wayne State University

Issued for Bids
8/26/2014

Prepared by

Connect With Confidence
Commonwealth
associates, inc.

320003 and 320004
Wayne State University
Physics & Engineering Building’s
Electrical Reliability Upgrades
August 26, 2014 – Issued for Bids

**Physics Building**

Building No. 663
666 W. Hancock
Detroit, MI 48201

**Engineering Building**

Building No. 90
5050 Anthony Wayne
Detroit, MI 48202

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# SECTION 017823 - OPERATION AND MAINTENANCE DATA

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

   1. Operation and maintenance documentation directory.
   2. Emergency manuals.
   3. Operation manuals for systems, subsystems, and equipment.
   4. Product maintenance manuals.
   5. Systems and equipment maintenance manuals.

### 1.3 DEFINITIONS

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

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

### 1.4 CLOSEOUT SUBMITTALS

A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

   1. Architect will comment on whether content of operations and maintenance submittals are acceptable.
   2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

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

   1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Architect.

      a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.

b. Enable inserted reviewer comments on draft submittals.

2. **Three** paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Architect**, through Construction Manager,** will return **two** copies.

C. Initial Manual Submittal: Submit draft copy of each manual at least **30** days before commencing demonstration and training. Architect **and Commissioning Authority** will comment on whether general scope and content of manual are acceptable.

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

1. Correct or revise each manual to comply with Architect's **and Commissioning Authority's** comments. Submit copies of each corrected manual within **15** days of receipt of Architect's **and Commissioning Authority's** comments and prior to commencing demonstration and training.

## PART 2 - PRODUCTS

### 2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information. Include a section in the directory for each of the following:

1. List of documents.
2. List of systems.
3. List of equipment.
4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

## 2.2 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

B. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

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

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

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

1. Binders: Heavy-duty, three-ring, vinyl-covered, **loose-leaf** binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch (215-by-280-mm) paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

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

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Supplementary Text: Prepared on 8-1/2-by-11-inch (215-by-280-mm) white bond paper.
5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

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

## 2.3 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.

8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

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

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

## 2.4 OPERATION MANUALS

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

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor has delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

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

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

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.

4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

## 2.5 PRODUCT MAINTENANCE MANUALS

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

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

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

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

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

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

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

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

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

## 2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

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

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

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

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

## PART 3 - EXECUTION

### 3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

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

D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

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

E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.
2. Comply with requirements of newly prepared record Drawings in Section 017839 "Project Record Documents."

END OF SECTION 017823

# SECTION 022280 – FLOWABLE FILL

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the furnishing and installation of flowable fill.

### 1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:

1. ASTM Standards, Specifications, Methods, Test Methods and Classifications:
    a. C33 - Specification for Concrete Aggregates.
    b. C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.
    c. C94 - Specification for Ready-Mixed Concrete.
    d. C136 - Sieve Analysis of Fine and Coarse Aggregates.
    e. C150 - Specification for Portland Cement.
    f. C260 - Specification for Air-Entraining Admixtures for Concrete.
    g. C618 - Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
2. ACI - American Concrete Institute:
    a. 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
    b. 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete.
    c. 304.2R - Placing Concrete by Pumping Methods.
    d. 305R - Hot Weather Concreting.
    e. 306R - Cold Weather Concreting.
3. MDOT:
    a. 2003 Standard Specifications for Construction.
    b. Standard Plans.

### 1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. Formwork: The design and construction of all formwork shall be the responsibility of Contractor.

B. Mix Proportions: Select flowable fill proportions according to the procedures specified herein to achieve the specified performance requirements.

### 1.5 SUBMITTALS

A. Design Data:

1. Submit flowable fill mix design.
2. Required Information:
    a. Dry weights of cement.
    b. Saturated surface-dried weights of fine aggregate.

    c. Quantities, type and name of all mix design contents.
    d. Weight of water.

## 1.6 QUALITY ASSURANCE

A. Installation Personnel Qualifications:
  1. Trained and experienced in the installation of the materials.
  2. Knowledgeable of the design and the reviewed mix designs.

B. Flowable Fill Supplier Qualifications:
  1. Ready-mix concrete producer.
  2. Experienced in design and control of flowable fill.

C. Testing of Flowable Fill: Not required.

## PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Cement:
  1. Portland cement, ASTM C150, Type I.
  2. Do not use different types or manufacturers of cement interchangeably without Engineer's approval.

B. Fly Ash: ASTM C618, Type C or F.

C. Aggregates:
  1. Grade aggregates according to procedures of ASTM C136.
  2. Fine aggregate: ASTM C33 or MDOT 902 Fine Aggregate 2NS.

D. Water: Clean, fresh, and potable.

E. Admixtures:
  1. Chlorides:
    a. No admixture shall contain more than 0.1% water soluble chloride ions by mass of cementitious material.
    b. No admixture shall contain calcium chloride.
  2. Air-Entraining: Daravair series or Darex series, by W.R. Grace & Company; Micro Air, by Master Builders; or equal.
  3. Stable Air Generator: Darafill, by W.R. Grace & Company; Flow-Air, by Axim Concrete Technologies; or equal.

## 2.2 MIXES

A. Mix Design Performance Requirements:
  1. Flowable fill which may be hand excavated in the future.
  2. Compressive Strength Range f'c: 40 to 75 psi at 28 days.
  3. Slump: 8 to 10 inches, minimum.
  4. Air Content: 15% to 35% utilizing stable air generator.

## 2.3 SOURCE QUALITY CONTROL

A. Production and Delivery:
  1. Batch, mix and transport flowable fill in accordance with ASTM C94.
  2. Furnish a delivery ticket with each batch of flowable fill before unloading at the Site, on which is printed, stamped or written the following information:
    a. Name of ready-mix batch plant.
    b. Serial number of ticket.
    c. Date and truck number.
    d. Name of Contractor.
    e. Job name and location.
    f. Specific class or designation of flowable fill.
    g. Amount of flowable fill (cubic yards).
    h. Time loaded or of first mixing of cement and aggregates.
    i. Type, name and amount of admixture.
    j. Type, brand and amount of cement and fly ash.
    k. Total water content by producer (or water-cementitious ratio).
    l. Maximum size of aggregate.
    m. Weight of fine aggregate.
  3. Flowable fill delivered in an outdoor temperature lower than 40 degrees F shall arrive at the Site of the Work having a temperature of not less than 50 degrees F and not greater than 90 degrees F unless otherwise specified or permitted by Engineer's representative.
  4. Complete the discharge of the flowable fill within 2-1/2 hours after introduction of mixing water to the cement or 2 hours after arriving at the Site, whichever is sooner.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Preplacement Inspection:
  1. Before placing flowable fill, inspect and complete the formwork installation.
  2. Notify other trades to permit the installation of their work; cooperate with other trades in setting such work, as required.

B. Components:
  1. Seal pipes, manholes and similar components not intended to be filled.
  2. Restrain from floatation.

### 3.2 PLACEMENT

A. General:
  1. Ensure flowable fill fills all cavities required to be filled.
  2. Avoid dislocation of components.
  3. Place in lifts if required to prevent floatation or to limit fluid pressures on formwork, walls, flexible wall pipe, or similar conditions.
  4. Wait 24 hours, minimum, between the start of subsequent placement lifts.

B. Handling:
  1. Handle flowable fill from mixer to place of final deposit in chutes, carts, buggies, conveyors, pumps or crane buckets.
  2. Do not deliver flowable fill by a method with a free fall of more than 3 feet.
  3. Take every possible precaution to prevent separation or loss of ingredients while transporting flowable fill.

C. Rate: Carry on placement at such a rate that flowable fill surfaces not yet to grade or lift shall not have reached their initial set before additional flowable fill is placed.

D. Retempering: Do not add water to the flowable fill once it has left the ready-mix plant.

E. Cold-Weather Operations:
  1. Comply with the recommendations of ACI 306R.
  2. Recommended Protective Measures:
    a. Heating materials.
    b. Providing insulating blankets and windbreaks.
    c. Use heated enclosures.
  3. Do not use frozen materials or materials containing ice or snow.
  4. Do not place on frozen subgrade.

F. Hot-Weather Operations:
  1. Comply with the recommendations of ACI 305R.
  2. Recommended Protective Measures:
    a. Cooling materials.
    b. Placement during cooler hours of the day.
    c. Providing shading and windbreaks.

## 3.3 PROTECTION

A. Cold Weather:
  1. Keep all freshly placed flowable fill from damage due to low temperatures when the mean daily temperature is below 40 degrees F (4.5 degrees C) in accordance with ACI 306R.
  2. Protect flowable fill from freezing until hardened, 36 hours minimum.

B. Loading: Protect flowable fill from construction, traffic or other loads until sufficient strength has been reached.

END OF SECTION 022280

# 023000

# EARTHWORK

## SECTION 023000 – EARTHWORK

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Work Included: Excavate and grade in the areas designated in the Contract Documents as shown on the grading plan and specified herein, which shall include but not be limited to, the following:

1. Excavation and site preparation.
2. Grading to establish subgrades for slabs, walks, pavements, gravel surfaces, and grassed areas.
3. Excavation, filling and backfilling and compaction.
4. Dewatering or addition of water as required.
5. Placing of topsoil and finish grading.

B. Related Sections: Additional Sections of the Documents which are referenced in this Section include:

1. Section 02315 - Excavation, Backfilling, and Compacting for Structures
2. Section 02317 - Excavation, Backfilling, and Compacting for Utilities
3. Section 02921 - Seeding

### 1.2 REFERENCES

A. General: The work shall comply with the most recent standards or tentative standards as published at the date of the contract and as listed in this specification using the abbreviation shown.

B. American Society for Testing and Materials (ASTM):

| | | |
|---|---|---|
| 1. | D 698 | Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft) |
| 2. | D 1556 | Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method |
| 3. | D 1557 | Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$)(2,700 kN-m/m$^3$) |
| 4. | D 2167 | Standard Test Method for Density and Unit Weight of Soil In Place by the Rubber Balloon Method |

| | | |
|---|---|---|
| 5. | D 2216 | Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass |
| 6. | D 2487 | Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| 7. | D 2922 | Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth) |
| 8. | D 2937 | Standard Test Methods for Density of Soil in Place by the Drive-Cylinder Method |
| 9. | D 3017 | Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth) |
| 10. | D 4318 | Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils |

## 1.3 DEFINITIONS

A. Controlled Fill: Controlled fill is fill required in all areas on which final grade is not placed on original excavated soil.

B. Unclassified Excavation: For the purposes of payment, material shall not be classified except for those items specifically listed in the Bid Form.

C. Unsuitable Material: For the purposes of classified excavation, unsuitable material shall be defined as material below subgrade elevation that exhibits excessive pumping or that does not meet density requirements due to unsatisfactory material as determined by Geotechnical Engineer.

D. Satisfactory Materials: Materials classified by ASTM D 2487 as GW, GP, GM, GC, SW, SP, SM, SC, ML, and CL are satisfactory as fill for overlot grading and are satisfactory in-situ. Materials shall have a minimum compacted density of 95 pounds per cubic foot and a plasticity index in excess of 15.

E. Unsatisfactory Materials: Materials classified by ASTM D 2487 as OL, OH, MH, CH, and PT are unsatisfactory in-situ and as fill. Unsatisfactory materials also include those materials containing roots and other organic matter, trash, debris, frozen materials, and stones larger than 6 inches. Fill materials containing stones larger than 3 inches shall not be used in the uppermost 2 feet.

F. Cohesionless and Cohesive Materials: Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the minus #40 fraction has a plasticity index of zero as classified by ASTM D 4318.

G. Degree of Compaction: Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 698 or ASTM D 1557 as specified, abbreviated below as a percent of laboratory maximum density.

H. Topsoil: Material obtained from excavations, suitable for topsoils shall consist of friable clay loam, free from roots, stones, other undesirable material and shall be capable of supporting a good growth of grass.

I. Geotechnical Engineer: A representative of a commercial geotechnical testing laboratory which will be used by the CONTRACTOR to provide the required quality assurance testing.

## 1.4 SYSTEM DESCRIPTION

A. Soil Bearing Capacity: Soil underneath all footings and structures shall have a minimum bearing capacity of 2,000 pounds per square foot.

## 1.5 SUBMITTALS

A. General: Submittals shall be in accordance with Division I requirements. Copies of all test results and field and office worksheets shall be furnished to the OWNER within 72 hours after the tests are complete.

B. Test Reports: The testing agency shall submit following reports, in duplicate, directly to OWNER from the testing services, with copy to the CONTRACTOR.

1. Test report on borrow material for soil classification.
2. Field density reports and map of test location.
3. One optimum moisture-maximum density curve for each type of soil used for controlled fill.
4. Other reports of any testing hereinafter specified deemed necessary by Soils Engineer or requested by the OWNER.
5. A test location plan shall be included with each submittal.

## 1.6 QUALITY ASSURANCE

A. Geotechnical Engineer: The CONTRACTOR shall retain a licensed independent Geotechnical Engineer and Test Laboratory approved by the OWNER to insure that earthwork meets the requirements of the specifications for density and moisture content. The Geotechnical Engineer shall attend the Pre-Construction Conference.

B. Inclement Weather: When fill operations are ceased due to weather (rain, freezing, snow, etc.), construction shall not be resumed until the Geotechnical Engineer has verified soil strength has not been adversely affected. If soil strength has been decreased, the affected portion of fill shall be rescarified, moistened, or dried as required and recompacted to the specified density.

C. Inspection: The CONTRACTOR shall conduct daily inspections and more often if necessary to verify that the specifications are being met for the installation of materials.

D. Coordination: The CONTRACTOR shall coordinate the work with the OWNER's Inspector by notifying the Inspector of scheduled work in advance. The CONTRACTOR shall coordinate work with other trades whose work will be affected on the site.

E. Utilities: Prior to any excavation the CONTRACTOR shall verify the locations of all utilities which may be in the area.

F. Drainage: The CONTRACTOR shall be responsible for the proper drainage of the site during construction of the project. Water shall not be allowed to accumulate in any of the excavated areas. Storm or ground water collecting on site during construction shall be removed by pumping, ditching, or other suitable means.

## 1.7 PROJECT CONDITIONS

A. Topographic Survey: Topographic information and boundary survey is by ?????????????

B. Test Borings: A subsurface investigation has been made at the site of the project in order to ascertain character of materials to be excavated. This information is provided for general information only. Attention is directed to the fact that these logs indicate materials encountered at boring locations only. Nothing in plans or specifications shall be taken as a guarantee that materials other than those disclosed by borings will be encountered or that proportions of various materials will not vary from those indicated. If the CONTRACTOR has any questions or desires additional information it is his responsibility to acquire this information at his own expense. All excavation for project is to be considered and bid as "unclassified" and no allowances will be made for rock encountered or removal and replacement of unsuitable material.

C. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of protection during earthwork operations.

1. Should uncharted, incorrectly charted, unmarked in field, or incorrectly marked in the field, piping or other utilities be encountered during excavation, CONTRACTOR shall consult utility OWNER immediately for directions. CONTRACTOR shall cooperate with OWNER and utility companies in keeping respective services and facilities in operation, and shall repair or arrange for repair, damaged utilities to satisfaction of utility owner.

2. CONTRACTOR shall demolish and completely remove existing underground utilities as indicated on the plans and shall coordinate with utility companies for shut-off of services if lines are active.

D. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

1. The CONTRACTOR shall operate warning lights as recommended by authorities having jurisdiction.

2. The CONTRACTOR shall protect structures, utilities, sidewalks, pavements, trees and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

3. The CONTRACTOR shall protect, maintain and restore bench marks, monuments, and other reference points affected by this work. If bench marks, monuments or other permanent reference points are displaced or destroyed, points shall be re-established and markers reset under supervision of a licensed Land Surveyor.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Materials: All fill materials shall be free from mud, refuse, construction debris, organic material, rock or gravel greater than 6 inches in any dimension, frozen or otherwise unsuitable material. Materials for fills shall be secured from excavation after rejection of any unsuitable materials. Materials from other sources may be used upon approval by the Geotechnical Engineer. Fill materials in the uppermost 2 feet shall not have any rocks larger than 3 inches in diameter.

B. Borrow: Material for use in replacing undercut areas or in construction of embankments shall be approved by the Geotechnical Engineer and obtained from approved sources.

C. Unsuitable Materials: Areas that exhibit excessive pumping or that do not meet density requirements due to unsuitable material as determined by Geotechnical Engineer shall be undercut and replaced with approved material in accordance with PART 3, EXECUTION.

## PART 3 - EXECUTION

### 3.1 TOPSOIL

A. Conservation of Topsoil: Topsoil shall be removed as required without contamination with subsoil and stockpiled convenient to areas for later application or at locations specified. Any surplus of topsoil from excavations and grading shall be stockpiled in location approved by the OWNER. A silt fence shall be installed on the downslope side and the stockpiles seeded.

B. Placing Topsoil: On areas to receive topsoil, the compacted subgrade shall be scarified to a 2 inch depth for bonding of topsoil with subsoil. Topsoil then shall be spread evenly and graded to the elevations and slopes shown. Topsoil shall not be spread when frozen or excessively wet or dry. All areas disturbed by work in this project shall be seeded in accordance with Section 02921 - Seeding.

### 3.2 EXCAVATION

A. Excavation: Excavation shall be unclassified except for those items specifically indicated in the Bid Form. After topsoil removal has been completed, excavation of every description, regardless of material encountered, within the grading limits of the project shall be performed to the lines and grades indicated. Satisfactory excavation material shall be transported to and placed in fill areas within the limits of the work. All unsuitable material including any soil which is disturbed by the CONTRACTOR's operations and surplus material shall be disposed of at locations off site secured by CONTRACTOR and approved by the OWNER. Excavations carried below the depths indicated, shall, except as otherwise specified, be refilled to the proper grade with satisfactory material as directed. All additional work of this nature shall be at the CONTRACTOR's expense, unless otherwise provided for in the Bid Form. Excavation and filling shall be performed in a manner and sequence that will provide drainage at all times. Excavations shall be kept free from water while construction therein is in progress. If the CONTRACTOR fails to provide adequate drainage and any material becomes soft or otherwise unsuitable as a result, such material shall be removed and replaced with satisfactory on-site material or borrow material from approved sources, or shall be dried and recompacted as directed by the Geotechnical Engineer at no additional cost to the OWNER.

B. Ditches, Gutters, and Channel Changes: Ditches, gutters, and channel changes shall be cut accurately to the cross sections and grades indicated. All roots, stumps, rock, and foreign matter in the sides and bottom of ditches, gutters, and channel changes shall be trimmed and dressed or removed to conform to the slope, grade, and shape of the section indicated. Care shall be taken not to excavate ditches and gutters below the grades indicated. Excessive ditch and gutter excavation shall be backfilled to grade either with compacted to specified densities material or with suitable stone or cobble to form an adequate gutter paving as directed. All ditches and gutters excavated under this section shall be maintained until final acceptance of the work. Satisfactory material excavated from ditches and channel changes shall be placed in fill areas. Unsuitable and excess material shall be disposed of in designated waste areas or as directed.

C. Unauthorized Excavation:

1. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific instruction from the OWNER or the Geotechnical Engineer.

2. Under footings or foundations, fill unauthorized excavations by extending the indicated bottom elevation of the footing or base to the unauthorized excavation bottom, but in no way altering the required top elevation.

3. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations, unless otherwise directed by the Geotechnical Engineer.

D. Stability of Excavations:_Maintain sides and slopes of excavations in a manner such that the excavation provides safety of personnel, protection of work, and compliance with requirements of governmental agencies having jurisdiction.

## 3.3 FILL

A. Preparation of Ground Surface for Fill: All vegetation such as roots, brush, heavy sods, heavy growth of grass, and all decayed vegetative matter, rubbish, and other unsatisfactory material within the area upon which fill is to be placed, shall be stripped or otherwise removed before the fill is started. In no case will unsatisfactory material remain in or under the fill area. The areas shall then be scarified to a depth of at least 6 inches, moistened or aerated as required and compacted with vibratory rollers, pneumatic rollers, sheepsfoot rollers or other mechanical means acceptable to the Geotechnical Engineer. Sloped ground surfaces steeper than one vertical to four horizontal on which fill is to be placed shall be plowed, stepped, benched, or broken up, as directed, in such manner that the fill material will bond with the existing surface. Prepared surfaces on which compacted fill is to be placed shall be wetted or dried as may be required to obtain the specified moisture content and density.

B. Fills and Embankments: Fills and embankments shall be constructed at the locations and to lines and grades indicated. The completed fill shall conform to the grading plan indicated. Approved material obtained during excavation may be used in forming required fill. Fill shall be satisfactory material and shall be free from roots, other organic material. No frozen material will be permitted in the fill. Stones having a dimension greater than 3 inches shall not be permitted in the upper 2 feet of fill or horizontal embankment. The material shall be placed in successive horizontal layers of 8 inches in loose depth for the full width of the cross section and shall be compacted as specified. Each layer shall be compacted before the overlaying lift is placed. Moisture content of the fill or backfill material shall be adjusted by wetting or aerating as necessary to provide the moisture content specified.

C. Backfilling Structures: Backfilling for structures shall be in accordance with Section 02315 – Excavation, Backfilling, and Compacting for Structures.

## 3.4 COMPACTION

A. Compaction: Each layer of the fill shall be compacted to at least 95 percent of the maximum theoretical density as determined by ASTM D 698. Moisture content shall be within +/-2 percent points of optimum as determined by ASTM D 2216. The top 1-foot of fill under pavement areas shall be compacted to 98 percent of maximum dry density as determined by ASTM D 698.

## 3.5 FINISHED GRADES

A. General: All areas covered by the project, including excavated and filled sections and adjacent transition areas, shall be uniformly smooth-graded. The finished surface shall be reasonably smooth, compacted, and free from irregular surface changes. The degree of finish shall be that ordinarily obtainable from blade-grader operations, except as otherwise specified. Ditches and gutters shall be finished to permit adequate drainage.

B. Unsatisfactory Material: Soft or otherwise unsatisfactory material shall be replaced with satisfactory excavated material or other approved materials.

C. Finished Elevations: Low areas resulting from removal of unsuitable material or from excavation of rock shall be brought up to required grade with satisfactory materials, and the entire area shall be shaped to line, grade, and cross section and shall be compacted as specified. The surface of embankments or excavated areas for road construction or other areas on which a base course or pavement is to be placed shall vary not more than 0.10 feet from the established grade and approved cross section. Surfaces other than those to be paved shall be finished not more than 0.20 feet above or below the established grade or approved cross section.

## 3.6 PROTECTION

A. Site Preservation: The CONTRACTOR shall protect newly graded areas from traffic and from erosion, and any settlement or washing away that may occur from any cause, prior to acceptance, shall be repaired and grades reestablished to the required elevations and slopes. All work shall be conducted in accordance with the Erosion Control provisions of these specifications.

B. Seeding: All areas disturbed by work in this project shall be seeded in accordance with Section 02921 - Seeding.

## 3.7 FIELD QUALITY CONTROL

A. Testing: Testing shall be the responsibility of the CONTRACTOR and shall be performed by an approved commercial testing laboratory qualified to perform such tests and approved by ENGINEER. Tests conforming to ASTM D 698, shall be made by the Geotechnical Engineer or his representative on each soil type found in the areas prepared to receive fill and in the soil to be used for fill. Field Density tests shall be made by the Geotechnical Engineer or his representative in accordance with ASTM D 1556 or ASTM D 2922 and ASTM D 3017 on the areas prepared to receive fill and on each layer of compacted fill. Testing shall be the responsibility of the CONTRACTOR and shall be performed at no additional cost to the OWNER. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted if necessary by the procedure described in ASTM D 2922, paragraph “ADJUSTING CALIBRATION CURVE”. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture gauges along with density calibration checks as described in ASTM D 3017. ASTM D 2937 shall be used only for soft, fine-grained, cohesive soils. At least one test shall be performed on the compacted backfill. More tests shall be performed if in the judgment of the Inspector or OWNER the compactive effort of the CONTRACTOR will not result in the specified density.

B. Testing Frequency: The following submittals are required.

1. A minimum of one moisture-density test shall be performed for each classification of fill material, and existing subgrade material.

2. One Atterberg limits test and one gradation analysis is required for every six field density tests.

3. Field density tests shall be performed as follows: a minimum of one test per lift per 5,000 square feet or fraction thereof is required for fill material and a minimum of one test per lift per 5,000 square feet or fraction thereof is required for subgrades prior to filling.

C. Visual Inspection: Upon completion of all excavation of unsuitable material, and for all footings, the Geotechnical Engineer shall visually inspect the subgrade and excavations. The visual inspection shall be conducted to assure that the data obtained from the test borings and used as a basis of design was representative of the site conditions. Upon completion of the inspection, the Geotechnical Engineer shall provide written notification to the OWNER.

D. Proof Rolling: Following visual inspection, CONTRACTOR shall demonstrate to the Geotechnical Engineer that the exposed subgrade does not contain previously unidentified soft areas by proof rolling. Proof rolling shall consist of rolling the entire surface with approved mechanical equipment while observing the subgrade for displacement or deformation.

END OF SECTION 023000

# SECTION 024119 – DEMOLITION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the demolition of existing walks, concrete pavements, parking lot and associated hard surface removals.

### 1.3 REFERENCES

A. Except as herein specified or as indicated on Drawings, the work of this Section shall comply with the following:
   1. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations.

### 1.4 DEFINITIONS

A. Terms:
   1. Abandon: Remove an item to the extent that it is not visible and does not interfere with new construction. Portions of the abandoned item may be left in place. No abandoned items shall be left below new footings.
   2. Demolish: Remove existing items from their present location in the Project area and haul to an area outside of the Project area. Remove utilities serving these items.
   3. Relocate: Move existing items from their present location to another location in the Project area. Extend utilities serving the present location to the new location.
   4. Remove: Remove existing items from their present location in the Project area and haul to an area outside of the Project area. Remove utilities serving these items.
   5. Replace: Remove existing items from their present location in the Project area, haul them to an area outside of the Project area, and furnish and install new items in the same or another location. Extend utilities serving the present location to the new location.
   6. Reuse: Move existing items from their present location to another location in the Project area. Extend utilities serving the present location to the new location.

### 1.5 PROTECTION

A. Comply with requirements of NFPA 241.

B. Existing Structures:
   1. Demolition and disassembly will not be allowed until it is coordinated with Owner's operations.
   2. Maintain free and safe passage to and from buildings.
   3. Prevent movement or settlement of structures.
   4. Provide and place bracing, shoring and underpinning, and be responsible for safety and support of structures and assume liability for such movement, settlement, damage or injury.

5. Cease operations and notify Engineer immediately if safety of structure appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.
6. All active utility mains traversing the project site shall be maintained.
7. Do not close or obstruct any streets, sidewalks, alleys or passageways unless specifically authorized.

C. Barricades:
   1. Provide, erect and maintain barricades, lighting and guard rails as required by applicable regulatory agencies to protect occupants of building and workers.
   2. Provide temporary fencing for security if it is necessary to temporarily remove Owner's security fencing for access to the site. Obtain Owner's approval prior to removing any existing fencing.
   3. Provide, erect and maintain temporary concrete barrier wall and appropriate temporary impact attenuators as required by applicable regulatory agencies to protect work zone, workers, vehicles and pedestrians.

D. Temporary Traffic Control Devices:
   1. Contractor shall provide, erect and maintain temporary traffic control signing, barricades, drums, markings, signal modifications, and related devices in accordance with the Michigan Manual on Uniform Traffic Control Devices (MMUTCD), Michigan Department of Transportation (MDOT), project plans and specifications and as directed by the Engineer.

E. Coordination With Local Authorities:
   1. Cooperate with local authorities and utility companies whose work affects or will be affected by the demolition operations. Ascertain the rules, regulations and requirements of these authorities which affect the demolition process; notify them of conditions affecting their work. Disconnect or arrange for disconnection of utility services if required.
   2. Comply fully with all provisions of the local codes, laws and ordinances applicable to work of this Section.

## 1.6 SUBMITTALS

A. Upon request, submit to Engineer for review 2 copies of proposed methods and operations of demolition of the structures and modifications specified herein prior to the start of work. Include in the submittal a schedule for the coordination of shutoff, capping and continuation of utility services as required.

B. Provide a detailed sequence of demolition, disassembly and removal work to ensure the uninterrupted progress of Owner's operations.

## 1.7 SEQUENCING AND SCHEDULING

A. Scheduling:
   1. Before commencing demolition work, install all traffic control devices, coordinate with applicable agencies and affected Owners, and complete all modifications necessary to bypass the affected structure.
   2. Actual work shall not begin until Engineer has inspected and approved the modifications and authorized commencement of the demolition work.
   3. Follow this procedure for each individual demolition operation.

## PART 2 - PRODUCTS

### 2.1 SALVAGED MATERIALS

A. Ownership:
   1. Owner will retain ownership of structure casting and grates.
   2. Owner shall have the option of retaining ownership of any or all existing equipment, materials, and items removed under this Work.
   3. Should Owner decide not to retain ownership of certain items removed under the work of this Section, those items shall become property of Contractor and shall be promptly removed from the Project Site.

B. Deliver items which remain property of Owner to a location, or locations, as selected by Owner.

### 2.2 MATERIALS

A. Weatherproof Closures: Polyethylene sheets or plywood.

B. Temporary Protective and Dustproof Partitions: Plywood, 2 x 4 wood studs and polyethylene sheets.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Permits: Obtain all necessary permits.

B. Weatherproof Closures: Erect weatherproof closures for exterior openings in tunnel.

C. Temporary Dustproof and Protective Partitions:
   1. Erect temporary partitions separating construction areas from occupied areas to prevent spread of dust, fumes and smoke to other parts of the plant and tunnels.
   2. On completion, remove partitions and repair damaged surfaces to match adjacent surfaces.

D. Be responsible for all safety requirements in accordance with the General Conditions.

E. Carry out demolition work to cause as little inconvenience to existing occupied building areas as possible.

### 3.2 DEMOLITION

A. General:
   1. Repair all demolition performed in excess of that required at no cost to Owner.
   2. Do not use explosives in the work.

B. Remove all demolished concrete, masonry, and other debris completely from within the work area.

C. Burning: Do not burn materials on Site.

D. Specific Items of Demolition: Listing of the following items is made solely for convenience and does not imply a complete schedule of demolition for this project. Refer to Drawings for extent and locations of various items of demolition work.

E. Disposal of Materials:
   1. Remove contaminated, dangerous and others materials from Site and dispose of in accordance with applicable regulations.
   2. Pay for all hauling, storage, collection and disposal costs.

## 3.3 CLEANING

A. Clean affected areas in accordance with Division 1.

END OF SECTION 024119

# SECTION 025230 – CONCRETE WALKS AND PAVEMENTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the furnishing and installation of concrete walks.

### 1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:

1. ASTM Publications:
    a. A820 - Steel Fibers for Fiber Reinforced Concrete.
    b. C33 - Specification for Concrete Aggregates.
    c. C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.
    d. C94 - Specification for Ready-Mixed Concrete.
    e. C136 - Sieve Analysis of Fine and Coarse Aggregates.
    f. C150 - Specification for Portland Cement.
    g. C260 - Specification for Air-Entraining Admixtures for Concrete.
    h. C309 - Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
    i. C330 - Specification for Lightweight Aggregates for Structural Concrete.
    j. C494 - Specification for Chemical Admixtures for Concrete.
    k. C618 - Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
2. ACI – American Concrete Institute:
    a. 117 - Standard Tolerances for Concrete Construction and Materials.
    b. 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
    c. 302.1R - Guide for Concrete Floor and Slab Construction.
    d. 303R - Guide to Cast-In-Place Architectural Concrete Practice.
    e. 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete.
    f. 305R - Hot Weather Concreting.
    g. 306R - Cold Weather Concreting.
    h. 309R - Guide for Consolidation of Concrete.
3. Americans with Disabilities Act (ADA).
4. MDOT:
    a. Standard Specifications for Construction
    b. Standard Plans.

### 1.4 SUBMITTALS

A. Provide mix design for concrete to be supplied.

B. Provide Manufacturer’s cut sheets for joint filler, sealant, and truncated domes.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Cement:
   1. Portland cement, ASTM C150, Type I.
   2. Do not use different types of cement, different manufacturers of cement, or different degrees of fineness.

B. Fly Ash: ASTM C618, Class F.

C. Aggregates:
   1. Grade aggregates according to procedures of ASTM C136, Class M, Exposure 4.
   2. Coarse Aggregates: ASTM C33-5S, Number 57 (1-inch), crushed limestone.
   3. Fine Aggregate: ASTM C33.

D. Water: Clean, fresh and potable.

E. Admixtures:
   1. General:
      a. No admixture shall contain more than 0.1% water soluble chloride ions by mass of cementitious material.
      b. No admixture shall contain calcium chloride.
   2. Air-Entraining:
      a. Comply with ASTM C260.
      b. Daravair series or Darex series, by W.R. Grace & Company; Micro Air, by BASF Admixtures, Inc.; or equal.

F. Curing Agents:
   1. Curing agents shall comply with ASTM C309.
   2. Provide approved products by Symons Corporation, W.R. Meadows, L & M Chemical, Master Builders or Dayton-Superior which are compatible with floor coatings or toppings specified.
   3. Compounds:
      a. Curing:
         1) 1100 Clear by W.R. Meadows.
         2) Day-Chem Rez Cure (J-11-W) by Dayton Superior.
         3) Resi-Chem Clear Cure by Symons.
         4) Confilm by Master Builders.
         5) L & M Cure by L & M Chemical.

G. Synthetic Fiber Reinforcing:
   1. Grace Fibers; Grace Micro Fibers; Fibermesh; Nycon Fibers; or equal.
   2. Specific Gravity: 0.9.
   3. Tensile Strength: 70 to 100 ksi.
   4. Length: 1/2-inch minimum; 1-inch maximum.
   5. 1.5 lb/cy.

### 2.2 CONCRETE MIX DESIGN

A. Design mix to project normal-weight concrete consisting of Portland cement aggregate, air-entrained add mixture and water producing the following properties:
   1. Compressive Strength: 4,000 psi (min) at 28 days.
   2. Air Content: 6% ±1%.
   3. Slump: 1 to 4 inches.
   4. Water Cement Ratio: 0.5 maximum.

B. Sand Cushions and Base Fill:
   1. Under sidewalk: 6-inches MDOT CLII sand.

C. Detectable Warning Ramp Stamps:
   1. In accordance with Americans With Disabilities Act (ADA).
   2. Armor-tile, Vetrified Polymer Composit (VPC), color yellow.
   3. East Jordan Iron Works (EJIW) Series 7005 cast iron warning plate.

## 2.3 FORM WORK

A. Provide necessary form work to provide concrete dimensions indicated on the Drawings ±1/2 inch.
   1. Forms to be straight and true, minimum 1 5/8-inch thick wood, full depth of concrete or steel forms.
   2. All curved radius pours to be smooth deflectable steel.

## 2.4 EXPANSION JOINTS

A. Joint fiber shall be preformed, composed of either blended, bonded flexible and waterproof fiber meeting the requirements of AASHTO M213 or polyvinyl chloride with fabric strand.

B. Reinforcement: Proflex by Oscoda Plastics; or approved equal.

C. Full depth of concrete.

## 2.5 SEALANTS

A. Joint sealant to be gray elastomeric silicone or polyurethane sealant conforming to ASTM 920: Sonoborn SL-2; or equal.

## PART 3 - EXECUTION

## 3.1 GRADING

A. Provide smooth base of granular material compacted to 98% of its maximum density in accordance with ASTM D1557.

## 3.2 INSTALLATION

A. Weather and Temperature Limitations:
   1. Do not place concrete when the temperature of the air is at or expected to drop below 40 degrees F for at least 7 days after placing.

2. Do not place concrete if portions of the base, subbase, or subgrade layer are frozen, or if the grade exhibits poor stability from excessive moisture levels.
3. Do not place concrete when the temperature of the air is above or expected to exceed 85 degrees F for at least 7 days after placing.

B. Cold Weather Concrete Operations:
   1. Comply with the recommendations of ACI 306R.
   2. Recommended Protective Measures:
      a. Heating materials.
      b. Providing insulating blankets and windbreaks.
      c. Heated enclosures.
   3. Advise Engineer of planned protective measures.
   4. Straw or similar materials shall not be allowed.
   5. Do not use frozen materials or materials containing ice or snow.
   6. Do not place concrete on frozen subgrade.

C. Hot Weather Concrete Operations:
   1. Comply with the recommendations of ACI 305R.
   2. Recommended Protective Measures:
      a. Cooling materials.
      b. Concrete placement during cooler hours of the day.
      c. Providing shading and windbreaks.
   3. Advise Engineer of planned protective measures.

D. Slope:
   1. All walks should have a cross slope of a minimum 1% and maximum 1.5% sloped toward a curb or lower elevation.
   2. No walks should exceed 5% longitudinal slope.

E. Preparation of Base:
   1. Excavate to the required depth and to a width that will permit forming.
   2. Remove unsuitable material below the required depth and replace with sound earth.
   3. Shape and compact the base to conform to the section indicated on the Drawings.

F. Forms:
   1. Use fixed forms.
   2. Apply form releasing agent to prevent concrete from bonding to forms.
   3. Provide straight, full depth forms free of warp and strong enough to resist springing during concrete placement.
   4. Firmly stake fixed forms to prohibit movement.

G. Placing and Finishing Concrete:
   1. Place all concrete in accordance with ACI 304R and ACI 304.2R.
   2. Moisten base before placing concrete.
   3. Place concrete and consolidate, including along the faces of the forms, before finishing.
   4. Place and finish in a continuous operation.
   5. When replacing gutters along with concrete walk ramps, construct the gutter to the same dimensions and profile and use the same reinforcement pattern as the existing gutter.
   6. Float the surface just enough to produce a smooth surface free from irregularities.
   7. Round edges and joints with an approved finishing tool.

8. Broom finish concrete walks and ramps by drawing a fine-hair broom across the concrete surface, perpendicular to the line of traffic. Repeat operation if required to provide a fine line texture acceptable to the Engineer.

H. Joints:
  1. General: Comply with ACI 318-6.3, 6.4, and ACI 301, Section 6. Construct expansion, weakened-plane (contraction), and construction joints true-to-line with face perpendicular to surface of concrete. Construct transverse joints at right angles to the centerline, unless otherwise indicated.
  2. Weakened-Plane (Contraction) Joints: Provide weakened-plane (contraction) joints, sectioning concrete into areas as indicated on the Drawings. Contraction joints for curbs shall be provided at 10 foot intervals and 20 foot spacing for slabs, unless shown otherwise. Construct weakened plane joints for a depth equal to at least 1/4 concrete thickness, as follows:
    a. Tooled Joints: Form weakened-plane joints in fresh concrete by grooving top portion with a recommended cutting tool and finishing edges with a jointer.
    b. Sawed Joints: Form weakened-plane joints using powered saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into hardened concrete as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.
  3. Construction Joints: Place construction joints at end of placements and at locations where placement operations are stopped for a period of more than 1/2 hour, except where such placements terminate at expansion joints.
  4. Expansion Joints: Provide premolded joint filler for expansion joints abutting concrete curbs, catch basins, manholes, inlets, structures, walks and other fixed objects, unless otherwise indicated. Locate expansion joints such that no single dimension exceeds 40 feet and also area between expansion joints not to exceed 250-square feet for sidewalks and at points of radii of curbs unless otherwise indicated.
  5. Extend joint fillers full width and depth of joint, and not less than 1/2 inch or more than 1 inch below finished surface for joint sealant.
  6. Furnish joint fillers in one-piece lengths for full width being placed, wherever possible. Where more than 1 length is required, lace or clip joint filler sections together.

I. Thickness: Except as otherwise specified or indicated on the Drawings, provide a minimum thickness of 8 inches.

J. Where walkways cross driveways, provide a minimum thickness of 8 inches.

K. Ramps:
  1. As indicated on the Drawings in accordance with City ADA requirements.
  2. No ramp shall exceed 1:12 slope.
  3. Place detectable warning domed plates in fresh concrete in accordance with Manufacturer’s instructions on ramp surface.
  4. Use colorized release agent to provide visual contrast with concrete walk.
  5. ADA domes to be 24 inches wide, full width of ramp.

L. Backfilling:
  1. After the concrete has gained sufficient strength, remove fixed forms and backfill with sound earth.
  2. Compact and level the backfill 1-inch below the surface of the concrete.

M. Concrete, Asphalt and Sawcutting Work:

1. The following requirements apply to concrete, sawcutting, and asphalt work (cutting, grinding, drilling, hydro-demolition, etc.):
    a. Discharge of water, dust, or debris from concrete and asphalt work to storm or sanitary systems is prohibited.
    b. Storm drains must be protected from dust and debris.
    c. Any water used during concrete and asphalt work (including sweeping and saw-cutting) must be contained and collected for proper disposal. Suggested controls include wet vacuum, or absorbents.
    d. Good housekeeping practices must be employed at the job site. Minimize dust.

N. Concrete Washout:
1. Do not discharge concrete washout into storm drains, catch basins or to the sanitary sewer system. Perform washing of concrete trucks in designated areas or offsite.
    a. Designated areas should be clearly labeled. They should be in a pit to prevent run-off of waste water. Place designated areas a minimum of 50 feet from storm drains, bodies of water and ditches. All designated areas should be lined to prevent seepage and should have a barrier.
    b. Alternative to a Designated Area: Provide a concrete box. If only a small amount of concrete washing is to occur, one option is to line a roll-off box. For very small projects this could be done with a drum.
2. Once concrete washout has hardened, break up and dispose of properly. Disposal of hardened concrete should occur on a regular basis.
3. Washout facilities must be cleaned, or new facilities provided once the washout area is 75% full.

O. Concrete Wastewater:
1. UM’s storm water permit required that all UM projects comply with the following:
    a. UM projects shall not discharge to the surface waters of the state any wastewater generated from cutting, grinding, drilling, or hydrodemolition of concrete without authorization under an NPDES wastewater discharge permit.

## 3.3 CONCRETE FINISHING

A. After striking-off and consolidating concrete, smooth surface by screening and floating. Use hand method only where mechanical floating is not possible. Adjust floating to compact surface and produce uniform texture.

B. After floating, test surface for trueness with a 10 foot straightedge. Distribute concrete as required to remove surface irregularities, and refloat repaired areas to provide a continuous smooth finish.

C. Work edges of slabs, and formed joints with an edging tool, and round to 1/2 inch radius, unless otherwise indicated. Eliminate tool marks on concrete surface.

D. After completion of floating and troweling when excess moisture or surface sheen has disappeared, complete surface finishing, as follows:
1. Exterior slabs, sidewalks, flow channels, flumes, curbs, and other similar concrete pavement types shall have a non-slip finish by scoring the surface with a fine-hair broom, perpendicular to the line of traffic. Repeat operation if required to provide a fine line texture acceptable to the Civil Engineer.

2. Retaining walls, wing walls, light pole bases, and other surfaces exposed to view upon completion of work shall be given a rubbed finish as specified below:
    a. Immediately upon removal of the forms, the surfaces to be rubbed shall be pointed up, thoroughly wetted and then rubbed with a No. 20 carborundum brick and water so as to produce a true, even, and smooth surface. When necessary to fill pinholes, and upon areas which have been reconstructed, rubbing shall be done by carborundum brick and a thin cement grout composed of 1 part of cement and 2 parts of fine washed silicone sand, all of which shall pass a No. 20 sieve. The surfaces finished with grout shall be carefully scraped with a steel edge so as to remove all surplus grout, after which it shall be given a final rub with a wood float until all skin and form marks shall be removed. No "wash" composed of cement and water, or cement, sand and water shall be used in this process.

E. Do not remove forms for 24 hours after concrete has been placed. After form removal, clean ends of joints and point-up any minor honeycombed areas. Remove and replace areas or sections with major defects, as directed by Civil Engineer.

## 3.4 CURING

A. General:
1. After texturing operations have been completed and after the free water has left the surface, coat the concrete walk surface and sides of slip-formed concrete walks with a uniform layer of membrane curing compound.
2. Apply 1 coat of curing compound on non-grooved surfaces and 2 coats on grooved surfaces.
3. Apply not less than 1 gallon per 25 square yards of concrete for each application.
4. Apply the second coat after the first has dried sufficiently but do not exceed 2 hours between coats.
5. Keep the compound thoroughly mixed according to the Manufacturer’s recommendations.
6. Do not thin curing compound.
7. Reapply curing compound immediately to surfaces damaged by rain, joint sawing, foot traffic or other activities.
8. If fixed forms are removed during the curing period, coat the entire area of the sides of the concrete walk with curing compound immediately after removal of forms.

B. These requirements are minimum requirements only. Repair or replacement of concrete showing damage due to inadequate curing is required. All costs associated with this corrective work will be borne by the Contractor.

## 3.5 ADA TRUNCATED DOMES

A. Prior to installation, review mix design with concrete supplier and installer to ensure concrete has proper slump and will not set too rapidly to allow for proper installation.

B. Install system in accordance with Manufacturer’s specifications and recommendations. Dome panels to be perpendicular and parallel with curb with no gaps between panels. Panels must be level and flush with adjacent concrete walk. Installation must be acceptable to construction manager or removed and replaced at Contractor’s expense.

## 3.6 PROTECTION

A. Protect the pavements from damage until acceptance of the Work.

B. Protect the concrete from freezing until the concrete has attained a compressive strength of at least 1000 psi.

C. Maintain walks as clean as practical by removing surface stains and spillage of materials as they occur.

D. Sweep concrete walks and wash free of stains, discolorations, dirt and other foreign material just prior to final inspection.

## 3.7 DEFECTIVE WORK

A. The following list of deficiencies shall be considered defective work and shall be replaced by the Contractor at no cost to the Owner:
   1. Difference in elevation between panels of 1/2-inch or greater.
   2. Cracks of any length that are 1/8-inch wide or wider.
   3. Surface spalling covering in excess of 20% of the area of any 1 panel.
   4. A hole that is 1/2-inch or greater in depth and 2 inches or greater in diameter.
   5. Residual splatter that is 1/2-inch or higher and attached to a panel.
   6. Elevation difference of 3/4-inch in 10 feet caused by settling, that has not caused an elevation difference between panels.
   7. Multiple hairline cracking.
   8. Footprints, bike tire tracks, animal tracks, or the like, created while concrete was not cured.

## 3.8 CLEAN-UP

A. For duration of work, Contractor is to maintain work area free of waste material, debris, and the like.
   1. Contractor shall provide on-site containers as necessary for work of this Section. Locate as directed by Construction Manager.

B. Upon completion and when directed by Construction Manager, Contractor shall remove all excess material, debris, and equipment occasioned by the work.

END OF SECTION 025230

# SECTION 031000 – CONCRETE FORMWORK

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the design, installation and removal of forms for cast-in-place concrete.

B. Related Sections include the following:
   1. Division 3 Section "Concrete Reinforcement."
   2. Division 3 Section "Concrete Accessories."
   3. Division 3 Section "Cast-In-Place Concrete."

C. Division of Work:
   1. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
      a. Mechanical, Electrical and Plumbing Trades: Supply, locate and install premanufactured items including inserts, sleeves, and other embedded items required by those respective trades.
      b. Formwork Subcontractor:
         1) Supply and install Site fabricated box-outs for chases, sleeves and other openings for mechanical, electrical and plumbing trades.
         2) Install other inserts, embedded parts, box-outs for openings, chases, reveals and recesses, except those specifically mentioned above that are by mechanical, electrical or plumbing trades. Special inserts, embedded parts or other special requirements needed by a specific trade shall be supplied by that trade to the formwork Subcontractor for installation.
      c. Contractor: Coordinate location of mechanical, electrical and plumbing inserts, embedded parts, openings and recesses with respective trades.

### 1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI - American Concrete Institute:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 301 - Standard Specifications for Structural Concrete for Buildings.
      c. 303R - Guide to Cast-In-Place Architectural Concrete Practice.
      d. 347R - Guide to Formwork for Concrete.

### 1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. Form Construction:

1. Provide required forms, shores, bracing, breast timbers, form ties, and accessories in sufficient quantities so as not to delay the Work, and of strength to support vertical and horizontal loads to which they are subjected.
2. Deflection: Maximum deflection of forms shall be 1/240 of span or 1/4-inch, whichever is less.

## 1.5 SUBMITTALS

A. Manufacturer's Literature: For form release agent**.**

## 1.6 QUALITY ASSURANCE

A. Design: The design and engineering of formwork, as well as its construction, shall be the responsibility of Contractor.

B. Notifications: Notify special inspector at least 24 hours in advance of placing concrete.

## PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Formwork Facing Materials:
  1. Smooth Form Finish Areas:
     a. Locations: All locations unless otherwise noted.
     b. The form facing material shall produce a smooth, hard, uniform surface on the concrete.
     c. Form facing materials may be plywood, tempered concrete-form-grade hardboard, metal, plastic, paper; or other approved material capable of producing the desired finish.
     d. Facing materials shall be supported by studs or other backing capable of preventing deflections in excess of those specified herein.
     e. Material with damaged surfaces, worn edges, patches, dents or other defects which will impair the texture of the concrete surface shall not be used.

B. Pan Forms:
  1. Steel or fiberglass, formed to profiles required to produce indicated shapes.
  2. Designed to be strong enough to carry construction live loads and the weight of plastic concrete without deflection detrimental to the structure.
  3. Formed for secure attachment to formwork platforms.
  4. Formed for removal in a manner which will not damage concrete.

C. Cylindrical Forms:
  1. Steel or fiberglass, formed to diameters required to produce indicated shapes.
  2. Strong enough to carry pressure of plastic concrete.
  3. Formed to produce shapes free from abrupt changes in shape, and to produce smooth uniform surface.

D. Void Forms:
  1. Degradable paper or cardboard forms, to suit slab and beam applications.

2. Strong enough to carry construction live load and the weight of plastic concrete without significant deformation.
3. Configurations to suit application indicated on the Drawings, as chosen by Contractor.
4. Sure Void Products, Inc.; or equal.

E. Chamfer Strips:
  1. Wood, metal, rubber, or PVC.
  2. Sizes as indicated, 3/4-inch x 3/4-inch minimum.

F. Form Ties:
  1. At Smooth Form Finish Areas:
    a. Factory fabricated metal ties.
    b. Removable or snap type, with tapered cones as required to leave no tie portion within 1-inch of concrete surface plane.
    c. Designed to leave no larger than a 7/8-inch diameter hole at concrete surface.
    d. Chosen by Contractor to suit application and to resist pressure of fresh concrete.
    e. For concrete tank walls, in addition to the above requirements, provide waterstop type feature on the tie.

G. Form Release Agent:
  1. Products for General Use: Magic Kote by Symons, Crete-lease 727 by Cresset Company; or equal.
  2. Chemically neutral agent in hydrocarbon solvent that will effectively prevent absorption of moisture and prevent bond with the concrete.

## PART 3 - EXECUTION

### 3.1 FORMWORK CONSTRUCTION

A. General:
  1. Install wall form ties in a regular repetitive pattern.
  2. Align and secure joints to avoid offsets.
  3. Provide chamfered strips in exposed corners of exterior corners, internal corners and for similar conditions throughout the Work.
  4. Construct forms to allow for installation of waterstops, bentonite waterproof bead, and waterproofing termination.
  5. Tie waterstops up to prevent folding when concrete is placed.
  6. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only.
  7. The arrangement of facing material shall be orderly and symmetrical with the number of seams kept to the practical minimum.
  8. Retighten forms after concrete placement if required to eliminate mortar leaks.
  9. Inspection Ports and Cleanouts:
    a. Provide temporary openings where interior area of formwork is inaccessible for cleanout and inspection.
    b. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar.
    c. Locate temporary openings on forms at inconspicuous locations.

B. Openings and Embedded Items:

1. Set and build into the work anchorage devices and other embedded items required for work that is attached to, or supported by, cast-in-place concrete.
2. Coordinate work of other Sections and cooperate with trade involved in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchor and other inserts.
3. Use setting drawings, diagrams, instructions and directions provided by Suppliers of the respective items.
4. Do not perform work unless specifically indicated on Drawings or reviewed prior to installation.

C. Cleaning:
   1. Clean forms as erection proceeds, to remove foreign matter.
   2. Remove cuttings, shavings and debris from within forms.
   3. Flush with water or use compressed air to remove remaining foreign matter.
   4. Ensure that water and debris drain to exterior through clean-out ports.
   5. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints.
   6. Thoroughly clean embedded waterstops and concrete surfaces prior to constructing forms for the next pour.

D. Applying Form Release Agent:
   1. Temperature of release agent and surfaces to which it is applied shall be a minimum of 70 degrees F.
   2. Apply by spray only.
   3. Uniformly coat surfaces with a thin film.
   4. Wipe off excess with clean towels.
   5. Apply in accordance with Manufacturer's recommendations.
   6. Do not allow to stand in puddles in the forms and prevent bonding of concrete at construction joints.

E. Provisions for Form Removal:
   1. Fabricate forms for easy removal without hammering or prying against the concrete surfaces.
   2. Kerf wood inserts for forming keyways, reglets, recesses and the like to prevent swelling and for easy removal.

## 3.2 FORM AND SUPPORT REMOVAL

A. Forms and supports shall remain in place for not less than the following periods of time:
   1. Tunnel Walls: 12 to 24 hours.
   2. Vault and Tunnel Top Slabs:
      a. Under 10 Feet Clear Span Between Supports: 96 hours (4 days).
      b. 10 to 20 Feet Clear Span Between Supports: 168 hours (7 days).
      c. Over 20 Feet Clear Span Between Supports: 240 hours (10 days).

B. In any event, do not remove forms and supports until concrete in walls has reached 30% of design strength, and in structural members and slabs has reached 75% of design strength.

C. Special precautions shall be taken when concrete is placed in average temperatures of 50 degrees F or below to ensure that forms are not removed before design strengths specified above are met.

D. If Contractor elects to use high-early-strength cement, the specified periods of time may be reduced as allowed by Engineer. This does not relieve Contractor of Contractor's liability.

E. Remove forms in such a manner and at such times as required to ensure safety of persons involved and so as to protect and maintain structural integrity of members.

F. Particular care shall be taken in removing forms to minimize damage to concrete surfaces; use crush or wrecking plates as necessary.

G. Whenever the formwork is removed, cure the exposed concrete as specified under Division 3 Section “Cast-in-Place Concrete.”

## 3.3 FIELD QUALITY CONTROL

A. Inspect and check completed formwork, shoring and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties and parts are secure.

B. Form Surface Repairs:
   1. Repair surfaces of forms to be reused in the work.
   2. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable.
   3. Apply new form release agent to new concrete contact form surfaces.
   4. Do not use patched forms for exposed concrete surfaces.

C. Special Inspections:
   1. Inform Engineer when formwork is complete and has been cleaned, to allow for inspection.
   2. Allow inspection of each section of plywood type of formwork prior to reuse.
   3. Obtain inspections prior to placing concrete.

END OF SECTION 031000

## 032000

## CONCRETE REINFORCING

## SECTION 032000 – CONCRETE REINFORCEMENT

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the furnishing and placement of concrete reinforcement.

B. Related Sections include the following:
   1. Division 3 Section “Concrete Formwork.”
   2. Division 3 Section “Concrete Accessories.”
   3. Division 3 Section “Cast-In-Place Concrete.”

### 1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 315 - Details and Detailing of Concrete Reinforcement.
      c. 315R - Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.
      d. 318 - Building Code Requirements for Reinforced Concrete.
   2. ASTM Specifications:
      a. A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   3. AWS:
      a. D1.4: Structural Welding Code - Reinforcing Steel.
   4. CRSI:
      a. Manual of Standard Practice.
      b. Reinforcing Bar Detailing.
      c. Placing Reinforcing Bars.

### 1.4 SUBMITTALS

A. Prepare Shop Drawings in accordance with ACI 315 and 315R and the CRSI Manual of Standard Practice and Reinforcing Bar Detailing. Include the following:
   1. Number, size, length, mark, and location of concrete reinforcement.
   2. Bending diagrams.

B. Certified Mill Test Reports:
   1. Submit upon request by Engineer.
   2. Showing physical and chemical analysis for each heat of reinforcement used on Project.

### 1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver reinforcement free of loose rust, scale, paint, oil and structural defects, and store on the site so as to maintain that condition.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. General:
  1. All concrete reinforcement and accessories shall be new, free from rust, scale, paint, oil and structural defects.
  2. Reinforcement shall be the sizes indicated on the Drawings.

B. Reinforcing Bars:
  1. ASTM A615.
  2. Yield stress: Fy = 60,000 psi.
  3. Deformed unless otherwise noted; smooth where specifically indicated on the Drawings.

C. Accessories:
  1. Chairs, bolsters, anchors, spacers, stirrups, ties and other devices as required for spacing and fastening reinforcement in place shall conform to CRSI Manual of Standard Practice.
  2. At exposed underside of concrete, use plastic-tipped chairs and bolsters.

### 2.2 FABRICATION

A. General:
  1. Fabricate reinforcement to the dimensions indicated on the Drawings and the reviewed Shop Drawings in accordance with the CRSI Manual of Standard Practice.
  2. Tolerances: As indicated in ACI 117.
  3. Bundle and tag reinforcement with suitable identification to permit checking, sorting and placing.
  4. Welding:
     a. Not permitted, unless specifically indicated on the Drawings.
     b. When permitted, comply with AWS D1.4.
     c. No tack welding permitted.

B. Hooks:
  1. Bend hooks in accordance with ACI 318.
  2. Extension on 90 degree hook shall satisfy the requirements of a standard hook unless indicated longer on the Drawings.
  3. Cold bend bars in such a way that will not damage the reinforcement.

C. Reinforcement with any of the following defects will not be permitted in the Work:
  1. Bar lengths, depths and bends exceeding specified fabrication tolerances.
  2. Bends or kinks not indicated on Drawings or reviewed Shop Drawings.
  3. Bars with reduced cross-section due to excessive rusting or other cause.

## PART 3 - EXECUTION

### 3.1 PLACEMENT

A. Place concrete reinforcement in accordance with:
   1. Shop Drawings reviewed by Engineer.
   2. CRSI Placing Reinforcing Bars and Manual of Standard Practice.
   3. Tolerances indicated in ACI 117.

B. Clearance:
   1. Preserve clear space between bars of not less than 1 times the normal diameter of round bars.
   2. In no case let the clear distance be less than 1-inch or less than 1-1/3 times the maximum size of aggregate.
   3. In the absence of specific cover requirements on the Drawings, provide the following minimum concrete cover for reinforcement:
      a. Cast Against and Permanently Exposed to Earth: 3 inches.
      b. Exposed to Earth, Weather or Water:
         1) No. 6 Through No. 18 Bars: 2 inches.
         2) No. 5 Bars, 5/8-Inch Wire and Smaller: 1-1/2 inches.
      c. Not Exposed to Weather or in Contact with the Ground:
         1) Slabs, Walls, and Joists:
            a) No. 14 and No. 18 Bars: 1-1/2 inches.
            b) No. 11 Bars and Smaller: 3/4-inch.
         2) Beams, Girders, and Columns: 1-1/2 inches.
         3) Shells and Folded Plate Members:
            a) No. 6 Bars and Larger: 3/4-inch.
            b) No. 5 Bars, 5/8-Inch Wire and Smaller: 1/2-inch.

C. Splices:
   1. Comply with ACI 318 and this Section.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.
   3. Laps of Circular Ring Tension Steel: Not less than 40 bar diameters.

D. Corner Bars:
   1. Provide corner bars for all horizontal wall steel.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.

E. Field Cutting and Bending: Field cutting or bending of bars will be permitted only under special conditions approved by Engineer.

F. Field Welding:
   1. In accordance with AWS D1.4.
   2. Only when specifically indicated on the Drawings.
   3. No tack welding permitted.

G. Slabs On Grade:
   1. Do not hook up welded wire fabric; either tie on supports at correct elevation, or lay on partial slab thickness of fresh concrete just prior to placing remainder of slab.
   2. For Chairs or Bolsters Resting on Soil, Place on Either:
      a. Sand plates.
      b. Concrete bricks set flush with soil to provide bearing surface for chairs or bolsters.

## 3.2 FIELD QUALITY CONTROL

A. Notification:
   1. Notify Engineer when reinforcing is in place so Engineer may review the reinforcement placement.
   2. Provide a minimum of 24 hours notice prior to placement of concrete.

END OF SECTION 032000

# SECTION 033000 – CAST IN PLACE CONCRETE

## PART 1 – GENERAL

### 1.1 SUMMARY

A. Work Included: Cast in place concrete.
  1. Spread footing foundation pads.
  2. Continuous wall footings and grade beams.
  3. Slab on grade.
  4. Elevated structural reinforced slabs.

### 1.2 QUALITY ASSURANCE

REFERENCE STANDARDS

A. Comply with the latest editions of the following design guides and standards:
  1. ACI 301 "Specifications for Structural Concrete for Buildings"
  2. ACI 302 "Guide for Concrete Floor and Slab Construction"
  3. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete:"
  4. ACI 305 "Hot Weather Concreting"
  5. ACI 306 "Cold Weather Concreting"
  6. ACI 311 "Recommended Practice for Concrete Inspection"
  7. ACI 315 "Details and Detailing of concrete Reinforcement"
  8. ACI 318 "Building Code Requirements for Structural Concrete"
  9. ACI 347 "Recommended Practice for Concrete Formwork"
  10. ACI SP-15 Field Reference Manual
  11. CRSI "Manual of Standard Practice"

### 1.3 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings for fabrication, bending, and placement of concrete reinforcement. Show bar bending schedules, stirrup spacing, diagrams of bent bars, and arrangements of concrete reinforcement. Include special reinforcement required for openings through concrete. Show elevation of reinforcement for all members at a minimum of ¼ inch – 1'-0" scale. Show locations of all construction and control joints.

B. Mix Designs: Submit proposed mix designs for concrete at least 15 days before start of concreting. Submittal shall include: cement content and type, admixture content and type, aggregate source and gradation, water content, air content, slump, yield, and documentation of average strength by field experience method or laboratory prepared trial mixtures in accordance with ACI 318 Article 4.3.

C. Product Data: Submit data and installation instructions for proprietary materials.

D. Material Certificates: Submit materials certificates certifying that each material complies with Specifications.

## 1.4 TESTING SERVICES

A. Owner will engage a testing laboratory acceptable to the Architect-Engineer to perform material evaluation tests and for quality control during placement.

B. Sample and test concrete for quality control during placement as follows:
   1. Sampling Fresh Concrete: ASTM C172 except modified for slump to comply with ASTM C94.
   2. Slump: ASTM C143 – one for each concrete truck, measured at point of discharge.
   3. Air Content: ASTM C231 pressure method – one for each truck load of ready-mixed air-entrained concrete.
   4. Temperature: Test concrete temperature hourly when ambient temperature is 40°F and below, and when 80°F and above.
   5. Compressive Strength Test: ASTM C39, one set of six cylinders for each 50 cubic yards or fraction thereof, of each concrete class placed in any one day, two lab specimens tested at 7 days, two lab specimens tested at 28 days and two specimens retained in reserve for later testing if required.

C. Test Reports
   1. Forward results to Architect-Engineer and Contractor on same day that tests are made.
   2. Reports of compressive strength tests shall contain the general information of project identification name and number, date of concrete placement, name of Contractor, name of concrete supplier, truck number and delivery ticket number, name of concrete testing agency, concrete type and class, name of individual making specimen, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; and the specific information of slump, air content, temperature, compressive strength and type of break for both 7-day and 28-day tests.
   3. Field reports of concrete inspection shall contain general information noted above, plus ambient temperature, concrete temperature, weather, slump, air content, and cylinder numbers.

D. Additional Testing

1. Testing agency shall make additional test of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure.
2. Testing agency shall conduct tests to determine adequacy of concrete cored cylinders complying with ASTM C42 or by other methods acceptable to Architect-Engineer.
3. Contractor shall pay for such tests conducted, and any other additional testing required, if concrete testing confirms specified strengths have not been met.
4.

## 1.5 JOB CONDITIONS

A. Store materials so as to ensure preservation of their quality and fitness for the Work. Store reinforcement and formwork in a manner to prevent damage and accumulation of dirt.

B. Contractor shall be responsible for correction of concrete work which does not conform to specified requirements, including strength, tolerances and finishes. Correct deficient concrete as directed by Architect-Engineer.

## PART 2 – PRODUCTS

## 2.1 MATERIALS

A. Formwork

1. Exposed Concrete: Unless otherwise shown or specified, construct formwork for concrete surfaces, which will be exposed to view in the completed project, with form plywood, metal or other acceptable panel-type material, to provide continuous, straight, smooth exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system show on Drawings. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.

2. Unexposed Concrete: Form concrete surfaces which will be unexposed to view in the completed Project with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and 1 side for tight fit.

B. Form Ties

1. Exposed Concrete: Plastic cone snap tie, Type 3M by Superior or accepted equal.

2. Unexposed Concrete: Snap-off metal ties, designed to prevent form deflection and prevent spalling surfaces upon removal. Portion remaining after removal shall be at least 1” from concrete surface.

C. Form Coatings: Commercial formulation form-coating compounds shall not bond with, stain, nor adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compound.

D. Reinforcement
   1. Deformed bars: ASTM A615, Grade 60.
   2. Welded Wire Fabric: ASTM A185. Furnish in flat sheets only.
   3. All chairs, spacers, clips, wire anchors and related items necessary to accurately space and secure reinforcement.
   4. Additional bars, if required, to anchor or space reinforcement.
   5. Chairs shall be plastic booted at points of bearing on forms for exposed concrete.
   6. Minimum 16-gauge annealed tie wire, ASTM A82.

E. Cement: ASTM C150, Type I or Type II.
F. Aggregates: ASTM C33 and as herein specified.
   1. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances with less that 10% passing the #100 sieve and less than 3% passing the #200 sieve.
   2. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam or foreign matter, as follows:
      a. Crushed stone: Processed from natural rock or stone for concrete slabs meeting MDOT ???????.
      b. Clean, sharp, natural or processed gravel, or, crushed stone, free from loam, clay, lumps, or other deleterious substances for footings and miscellaneous concrete.
      c. Maximum aggregate Size: Footings and Walls – 1 ½ “, Slabs – ¾”.
G. Water: Clean, fresh, and potable.
H. Air Entraining: ASTM C260.
I. Water Reducing Admixture: ASTM C494, Type A.
J. Non Corrosive, Non Chloride Accelerator: ASTM C494, Type C or E.
K. Prohibited Admixtures: Calcium chloride, thiocyanates. Admixtures containing more than 0.05% chloride ions are not permitted.
L. Evaporation Retarder: Confilm by Master Builders, or accepted equal.
M. Curing Sheet Materials: ASTM C171, including waterproof paper, polyethylene film or polyethylene coated burlap.
N. Liquid Membrane Curing/Sealing Compound: Masterkure by Master Builders or accepted equal.
O. Exterior Anti-Spalling Sealer: Penetrating Sealer 40 by Sonneborn or approved equal.
P. Hardener: Lapidolith by Sonneborn or approved equal.
Q. Mineral Aggregate Floor Surface Hardener: Colorcron by Master Builders or approved equal. French gray color. Apply at rate of 1.00 pounds per square foot.

R. Joint Filler: ½" thick ASTM D994 premolded expansion joint filler strips; vinyl removable filler cap strip, 940 Series by Green Streak or approved equal.
S. Sleeves: ASTM A120, Hot-dipped galvanized.
T. Anchor Bolts: Furnished in Section 05100 ande installed under this Section.
U. Dowel Bars: 1-inch square steel bars with ¼-inch compressible foam on vertical faces; or 1-inch diameter steel bars, greased.
V. Non-shrink Grout: Sonogrout 14 by Sonneborn, or approved equal.
W. Water Stop: Volclay Waterstop RX, 1' x 3/4"' by American Colloid Co. or approved equal.
X. Dovetail Slot: Standard Dovetail Slot #180, 26 gauge galvanized steel with foam filler by Heckmann Building Products or approved equal.

## 2.2 PROPORTIONING AND MIX DESIGN

A. Prepare design mixes for concrete. Use independent testing facility acceptable to Architect-Engineer for preparing and reporting proposed mix designs.

B. Where the concrete production facility can establish the uniformity of its production for concrete of similar strength and materials based on recent test data, the average strength used as a basis for determining mix design proportions shall exceed the specified design strength by the requirements of ACI 318, section 4.3.2 or ACI 301, Section 3.9.

C. Concrete Quality

| **Location** | **Required 28 day Compressive Strength** | **Maximum Water/Cement Ratio** | **Air-Content** | **Unit Weight** |
|---|---|---|---|---|
| Footings, foundation walls and all other below grade concrete, miscellaneous concrete | 3,000 psi | 0.55 | 4% - 6% | 147 – 153 pcf |

| **Location** | **Required 28 day Compressive Strength** | **Maximum Water/Cement Ratio** | **Air-Content** | **Unit Weight** |
|---|---|---|---|---|
| Interior slab on grade | 4,000 psi | 0.45 | 0% | 147 – 153 pcf |
| Elevated structural slabs | 4,000 psi | 0.45 | 0% | 147 – 153 pcf |
| Exterior concrete | | | | |

| | | | | |
|---|---|---|---|---|
| subject to freezing and thawing, exterior slab on grade | 4,000 psi | 0.45 | 5% - 7% | 147 – 153 pcf |
| Interior elevated structural lightweight slab | 4,000 psi | 0.45 | 4% - 6% | 114 – 120 pcf |

D. Slump

1. Footings and Foundation Walls: 3” to 5”.
2. Slabs: 4” maximum.

E. Ready Mix Concrete: ASTM C94.

F. The quantity of coarse aggregate in pounds must be in the range of 1.25 to 1.5 times the quantity of fine aggregate in pounds.

G. Fly ash may be substituted for cement for interior slabs only, at a maximum rate of 15 percent by weight. Submittals shall include actual mix design, including percentage of fly ash and test results showing that mix meets specified compressive strength, and air content. Fly ash is not permitted in cold weather concreting unless extended protection is provided. Protection and heat shall be maintained until 70 percent of specified design strength is achieved.

H. Pumping of concrete is permitted only if mix designs specifically prepared and used previously for pumping are submitted. Pumpline shall have a 5-inch minimum inside diameter and shall be used with 5-inch pumps.

## 2.3 REINFORCING FABRICATION

A. Fabricate bars to required lengths, shapes and bends. Do not rebend or straighten reinforcement in a manner that shall weaken the material

## 2.4 FORMWORK

B. Design formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure.

## PART 3 – EXECUTION

## 3.1 INSPECTION

A. Examine conditions under which concrete shall be placed. Do not proceed with work until all unsatisfactory conditions are corrected..

## 3.2 NOTIFICATION

A. Notify Architect-Engineer 24 hours before anticipated time of completion of reinforcement in any section.

B. Do not place concrete until reinforcement has been observed and corrections, if any, made.

## 3.3 FORMWORK INSTALLATION

A. Erect, brace, and maintain formwork to support vertical and lateral loads.

B. Construct forms to sizes, lines and dimensions shown to obtain accurate alignment, location, grades, level and plumb work in finished structure.

C. Provide for openings, offsets, keys and other features required in work. Accurately position and support items.

D. Solidly butt joints and provide backup at joints to prevent leakage of cement paste.

E. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.

F. Kerf wood inserts for forming keys and the like to prevent swelling and for easy removal.

G. Provide openings in concrete form to accommodate work of other trades. Determine size and location of openings, recesses and chases from trades providing such.

H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retighten forms after concrete placement if required to eliminate concrete leaks.

I. Reuse of Forms: Clean and repair surfaces of forms to e reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material is not acceptable. Apply new form coating compound material. When forms are reused for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets.

## 3.4 REINFORCEMENT PLACING

A. Clean reinforcement of loose rust, mill scale, earth, ice and other materials which reduce or destroy bond with concrete.

B. Accurately position, support and secure reinforcement against displacement by formwork, construction or concrete placement operations. Locate and support reinforcement by metal chairs, runners, bolsters, spacers and hangers as required. Do not use brick.

C. Place reinforcement to obtain at least the minimum coverage's for concrete protection.

D. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. Lap bar splices as indicated. Stagger splices in adjacent bars. Wire tie all splices.

## 3.5 WELDED WIRE FABRIC REINFORCEMENT PLACEMENT

A. Place welded wire fabric one-third of the slab thickness below top surface of slab.

B. Place flat sheets in as long lengths as practical. Lap adjoining sheets at least one full mesh. Offset laps to prevent continuous laps in either direction.

C. Do not continue welded wire fabric through any control joints or construction joints for slabs on grade.

## 3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, reinforcing steel and items to be embedded or cast in the concrete.

B. Notify other trades to permit installation of their work. Cooperate with other trades in setting such work as required.

C. Install anchor bolts and sleeves.

D. Deposit concrete continuously or in layers of such thickness that no concrete shall be placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within section. Provide construction joints if section cannot be placed continuously.

E. Deposit concrete as nearly as practicable to its final location to avoid segregation caused by rehandling or flowing.

F. Keep excavations free of water. Do not deposit concrete in water, mud, snow or on frozen ground.

G. Maximum drop of concrete shall not exceed 5 feet. Use hopper and trunk for greater drops.

H. Contractor shall be responsible for controlling the proper placing of all embedded pipe, conduit and other embedded items.

I. Contractor shall be responsible for finishing of all concrete slabs to proper elevations to insure that all surface moisture will drain freely to floor drain, and that no puddle areas exist. During finishing operation, Contractor shall pay particular attention to this criterion, and shall make all efforts to obtain this. Any cost of corrections to provide for this positive drainage will be the responsibility of Contractor.

## 3.7 CONSOLIDATION

A. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand spading, rodding or tamping.

B. Do not use vibrators to transport concrete inside formwork.

C. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.

D. Do not allow vibrator to come in contact with form.

## 3.8 SURFACE FINISHES

A. Finish of Formed Surfaces:
  1. Rough Form Finish: For formed concrete surfaces not exposed to view in the finished work or concealed by other construction unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding ¼” in height removed.
  2. Smooth Form Finish: For formed concrete surfaces exposed to view. This is as cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed. Lightly rub all exposed surfaces to achieve a uniform appearance. Or Lightly sandblast to expose fine aggregate with occasional exposure of coarse aggregate and to make the color uniform.

B. Monolithic Slab Finishes
  1. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile, and other bonded applied cementitious finish

flooring material. After placing slabs, roughen surface before final set with stiff brushes, brooms or rakes.

2. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with carpet, resilient flooring, paint or other thin film finish coating system. After floating, begin first trowel finish operation using a power drive trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand trowel operation, free of trowel marks.
3. Non-Slip Broom Finish: Apply non-slip broom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated. Immediately after trowel finishing, slightly roughen concrete surface by brooming with a fiber bristle broom perpendicular to main traffic route.

## 3.9 APPLICATION OF FLOOR SURFACE HARDENER

A. Bleed water shall not be present before or during the application of this shake.

B. Apply first shake to hand floated concrete adjacent to forms, entryways, columns and walls where moisture will be lost first. Apply two-thirds of the specified total shake immediately following floating of total area. Distribute evenly by hand broadcasting in all areas.

C. Finishing machines with float shoes shall be used as soon as shake has absorbed moisture (indicated by darkening of surface and when surface is firm enough to support a float machine and operator). Float just sufficiently to bring moisture from base slab through the shake. Immediately following floating, apply remaining one-third of total specified shake in the same manner, allow the hardener to darken and machine float as specified.

D. At no time shall water be added to the surface.

E. As surface further stiffens, indicated by loss of sheen, it shall be hand or mechanically trowelled with blades relatively flat. All marks and pin holes shall be removed during the final trowel operation. Finish troweling to produce a light swirl finish to provide skid resistance.

## 3.10 CURING AND PROTECTION

A. Concrete shall be protected from premature drying, excessively hot or cold temperature, and mechanical injury according to provisions of ACI 301, Chapter 12. During placing, all concrete flatwork exposed to or subject to rapid evaporation of moisture under drying conditions (including hot weather, low humidity, wind and/or sunlight) shall be protected immediately following screeding with evaporation retarder applied in accordance with recommendations of manufacturer. Application shall precede and shall be in addition to curing specified below.

B. Concrete shall be maintained in a continuously moist condition for at least 7 days after placement. Curing shall begin as soon as possible after concrete has been placed and finished. Materials and methods of curing shall be submitted to Architect-Engineer for review and approval.

C. Curing and Protection: Surfaces not in contact with forms and surfaces in contact with forms for less than seven days.
   1. Curing shall be by water curings, application of liquid membrane curing/sealing compound or by application of sheet curing materials. Curing compounds shall be applied in accordance with manufacturer's recommendations. Liquid membrane curing compound used on floor slabs receiving applied finish flooring shall be guaranteed by the manufacturer, in writing, not to impair bonding of adhesive.
   2. For slabs use a curing treatment of water curing, curing sheet materials, or by applying and removing curing/sealing compound. The curing compounds must be applied immediately after final finishing. For curing by water curing or curing sheet materials, the concrete must be continually moist-cured for at least 7 days. Curing shall begin immediately after finishing.
   3. For other surfaces (footing, walls, etc.) curing shall be by one of the accepted curing treatments listed above.
   4. Restore curing protection on all freshly cut joint edges and faces when sawing joints or removing forms.

D. Concrete placed under cold weather conditions shall be cured by completely covering exposed surface of concrete with curing sheet materials with sheets completely sealed around edges. All concrete shall be cured for a minimum of 14 days with temperatures at or above 40°F or for a minimum of 7 days with temperatures at or above 70°F.

## 3.11 COLD WEATHER CONCRETING

A. Place concrete during cold weather in accordance with ACI 306.

B. For cold weather concreting, (defined as a period when for more than three successive day the mean daily temperature drops below 40°F) concrete temperature shall be maintained in accordance with ACI 306.

## 3.12 HOT WEATHER CONCRETING

A. Place concrete in accordance with ACI 305.

B. Cool ingredients before mixing to maintain concrete temperature below 90°F at time of placement.

C. Cover reinforcing steel with water-soaked burlap if temperature of reinforcing steel exceeds ambient air temperature.

D. Wet forms thoroughly before placing concrete.

## 3.13 WALL JOINTS

A. Construction Joints: Locate and install construction joints as shown on Drawings. Where construction joints are not shown, locate joints at masonry control joints. Install joints maximum of 60 feet on center in locations acceptable to Architect-Engineers.

## 3.14 INTERIOR SLAB JOINTS

A. Construction Joints: Locate and form construction joints as shown on Drawings. Where construction joints are not shown, place in locations acceptable to Architect-Engineer.

B. Contraction Joints: Saw cut joints as soon as possible after finishing generally within 4 to 16 hours. Make sample cut to determine if concrete surface is firm enough so that it is not torn or damaged by the blade.

C. Isolation Joints: Construction isolation in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

## 3.15 EXTERIOR SLAB JOINTS

A. Expansion Joints: Locate and install expansion joints as shown on Drawings. Where expansion joints are not shown, locate and install joints a maximum of 20 feet on center in either direction.

B. Contraction Joints: Tool joints during final finishing with edging tool.

C. Isolation Joints: Construct isolation joints in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

## 3.16 TOLERANCES

A. Footings
  1. Variation of dimensions in plan: plus 2” or minus ½”.
  2. Variation of center from specified center in plan: 2 percent of footing width in direction of variation, plus or minus 2” maximum variation.
  3. Variation of bearing surface from specified elevation: plus or minus ½”.

B. Anchor Bolts and Sleeves
  1. Variation from specified location in plan: plus or minus ¼”.
  2. Variation from specified elevation: plus or minus ½”.

C. Slab on Grade
  1. Surface Flatness: $F_F$ = 20 or greater.
  2. Surface Levelness: $F_L$ = 17 or greater.
  3. Variation from specified elevation: plus or minus ¼”.

D. Stairs
  1. Variation in riser: 1/8”.
  2. Variation in tread: 1/8.

## 3.17 SLAB SEALERS

A. Interior Exposed Slabs: Apply two coats of hardener after slabs have cured a minimum of 28 days at a rate of 100 square feet/gallon; in accordance with manufacturer's recommendations.

B. Exterior Exposed Slabs: Apply two coats of Penetrating Exterior Anti-Spalling Sealer after slabs have cured a minimum of 28 days in accordance with manufacturer's recommendations.

## 3.18 REPAIR OF SURFACES

A. Contractor shall be responsible for cost of repairing defects.

B. Repair defective wall areas with cement mortar or proprietary patching compound, when acceptable to Architect-Engineer. Cut out honeycomb, rock pockets and voids over 1/2" inch diameter back to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to concrete surface.

C. Repair defective interior slab areas as follows:
   1. Correct flatness and levelness defects by grinding or removal and replacement of slab. Patching of low spots will not be permitted.
   2. For cracks less than 1/32 inch, no repairs are required. For cracks greater than 1/32 inch, use crack repair material. For cracks over 1/8 inch, fill crack with oven-dried sand prior to application of crack repair material, as recommended by manufacturer. Contractor also has option to remove and rebuild areas of cracking. Mask cracks to limit crack repair material to crack only.
   3. Curling at slab edges which exceeds ¼ inch when measured with a 10-foot straight edge shall be made level by grinding or planning. Straightedge shall be located with it's end at the slab edge, and the space between the straightedge and the slab be measured. If curling exceeds ¼ inch, core drill slab at 3-foot intervals and inject non-shrink grout to fill void beneath slab.
   4. Repair edge spalls which occur from shrinkage cracking or from contractor's operations.

D. Remove and replace all exterior slabs which are cracked or do not drain properly.

END OF SECTION 033000

# 034100

# PRE-CAST CONCRETE

## SECTION 034100 – PRE-CAST CONCRETE

## PART 1 - GENERAL

### 1.1 SECTION INCLUDES

A. This specification covers the materials for the manufacture of precast reinforced concrete units produced in accordance with the plans and these specifications.

### 1.2 REFERENCES

Where applicable, the latest editions of the following standards shall be considered a part of these specifications. In case of conflict, these specifications shall take precedence over the listed standard. (See also Article 2.4, Concrete Materials.

A. American Association of State Highway and Transportation Officials (AASHTO)

1. “Standard Specification for Highway Bridges”
2. “Guide Specifications for Structural Design of Sound Barriers”

B. American Concrete Institute

1. ACI 304 – Guide for Measuring, Mixing, Transporting and Placing Concrete
2. C. ACI 318 – Building Code Requirements for Structural Concrete

C. American Society for Testing and Materials

1. ASTM C478 – Specification for Precast Reinforced Concrete Manholes Sections
2. ASTM C825 – Standard Specification for Precast Concrete Barriers
3. ASTM C857 – Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
4. ASTM C858 – Standard Specification for Underground Precast Concrete Utility Structures
5. ASTM C890 – Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
6. ASTM C913 – Standard Specification for Precast Concrete Water and Wastewater Structures
7. ASTM C915 – Standard Specification for Precast Reinforced Concrete Crib Wall Members
8. ASTM C923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
9. ASTM C936 – Standard Specification for Solid Concrete Interlocking Paving Units
10. ASTM C990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
11. ASTM C1227 – Standard Specification for Precast Concrete Septic Tanks
12. ASTM 1433 – Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers

13. ASTM C1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals

D. American Welding Society

1. AWS D1.1 – Structural Welding Code – Structural Steel
2. AWS D1.4 – Structural Welding Code – Reinforcing Steel

E. CRSI Manual of Standard Practice

## 1.3 FRANCHISE PRODUCTS

A. Products manufactured under franchise arrangements shall conform to all the requirements specified by the franchiser. Items not included in the franchise specification but included in this specification shall conform to the requirements in this specification.

## 1.4 SUBMITTALS

A. Product Data

1. For standard precast concrete units, the precast concrete producer will supply cut sheets showing conformance to project drawings and requirements and to applicable ASTM specifications listed in this specification. The Precast concrete producer shall certify that such products will meet the ASTM specifications.
2. For proprietary precast concrete units, the precast concrete producer may supply standard plans or informative literature. Supporting calculations and design details shall be available upon request. The Precast concrete producer shall warrant that such products will perform the intended task.

B. Shop Drawings

1. The plans for custom-made precast concrete units shall be shop drawings furnished by the precast concrete producer for approval by the Owner or his agent (specifier). These drawings shall show complete design, installation, and construction information in such detail as to enable the Owner to determine the adequacy of the proposed units for the intended purpose. Details of steel reinforcement size and placement as well as supporting design calculations, if appropriate, shall be included. The drawings shall include a schedule, which will list the size and type of precast concrete units at each location where they are to be used. The precast concrete units shall be produced in accordance with the approved drawings.

## 1.5 QUALITY ASSURANCE

A. Precast concrete producer shall demonstrate adherence to the standards set forth in the National Precast Concrete Association Quality Control Manual. Precast concrete producer shall meet requirements written in subparagraph 1 or 2.

1. NPCA Certification - The precast concrete producer shall be certified by the National Precast Concrete Association's Plant Certification Program prior to and during production of the products for this project.
2. Qualifications, Testing and Inspection
   a. The Precast concrete producer shall have been in the business of producing precast concrete products similar to those specified for a minimum of 5 years. The precast concrete producer shall maintain a permanent quality control department or retain an independent testing agency on a continuing basis. The agency shall issue a report, certified by a licensed engineer, detailing the ability of the precast concrete producer to produce quality products consistent with industry standards.
   b. The Precast concrete producer shall show that the following tests are performed in accordance with the ASTM standards indicated. Tests shall be performed for each 150 cu. yd. of concrete placed, but not less frequently than once per week.
      1) Slump: C143
      2) Compressive Strength: C31, C192, C39
      3) Air Content (when air-entrained concrete is being used): C231 or C173
      4) Unit Weight: C138
   c. The Precast concrete produced shall provide documentation demonstrating compliance with this subparagraph.
   d. The Owner may place an inspector in the plant when the products covered by this specification are being manufactured.

## 1.6 DELIVERY, STORAGE AND HANDLING

A. Handling

1. Products shall be stored, handled shipped and unloaded in a manner to minimize damage. Lifting holes or inserts shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose.
2. Acceptance at Site
   a. The Owner’s representative shall make final inspection and acceptance of the precast concrete products upon arrival at the jobsite.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURES

A. The precast concrete manufacturer must meet the guidelines written in article 1.5 paragraph A.

## 2.2 MANUFACTURED PRECAST UNITS

A. Precast Concrete: Provide all units shown in Contract Documents and as needed for a complete and proper installation.

B. Design Criteria – Design units in accordance with:

1. ___________ building code.
2. ACI 304 and 318.
3. CRSI Manual of Standard Practice.
4. Applicable ASTM Standards.

C. Finishes

1. Formed non-architectural surfaces: Surfaces cast against approved forms using industry practice in cleaning forms, designing concrete mixes, placing and curing concrete. Normal color variations, form joint marks, small surface holes caused by air bubbles, and minor chips and spalls will be tolerated but no major imperfections, honeycombs or other defects will be permitted.
2. Unformed surfaces: Surfaces finished with a vibrating screed, or by hand with a float. Normal color variations, minor indentations, minor chips and spalls will be tolerated but no major imperfections, honeycombs, or other defects shall be permitted.
3. Special finishes:
   a. Troweled, broom or other finishes shall be according to the requirements of project documents and performed per industry standards or supplier specifications.
   b. Precast concrete producers shall submit finishes for approval when required by the project documents. The sample finishes shall be approved prior to the start of production.

D. Patching and Repairs

1. No repair is required to formed surfaces that are relatively free of air voids and honeycombed areas, unless the surfaces are required by the design to be finished.
2. Repairing Minor Defects - Defects that will not impair the functional use or expected life of a manufactured precast concrete product may be repaired by any method that does not impair the product.
3. Repairing Honeycombed Areas - When honeycombed areas are to be repaired, all loose material shall be removed and the areas cut back into essentially horizontal or vertical planes to a depth at which coarse aggregate particles break under chipping rather than being dislodged. Proprietary repair materials shall be used in accordance with the manufacturer's instructions. If a proprietary repair material is not used, the area shall be saturated with water and, immediately prior to repair, the area should be damp, but free of excess water. A cement-sand grout or an approved bonding agent shall be applied to the chipped surfaces, followed immediately by consolidating an appropriate repair material into the cavity.
4. Repairing Major Defects - Defects in precast concrete products which impair the functional use or the expected life of products shall be evaluated by qualified personnel to determine if repairs are feasible and, if so, to establish the repair procedure.

## 2.3 MATERIALS

A. Concrete - Concrete shall be a uniform mix of quality materials listed in Article 2.4. Mix proportions shall be determined by following the standards in ACI 318 Chapter 5.

Recommendations for selecting proportions for concrete are given in detail in Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete (ACI 211.1). Recommendations for lightweight concrete are given in Standard Practice for Selecting proportions for Structural Lightweight Concrete (ACI 211.2).Retain "Insulated Conductors" Paragraph below to require one of the two preferred conductor materials permitted by NFPA 70; delete to allow Contractor to use any material that complies with Code. See "Grounding Products" Article in the Evaluations for discussion on alternative materials.

1. Water-Cement Ratio
    a. Concrete that will be exposed to freezing and thawing shall contain entrained air and shall have water-cement ratios of 0.45 or less. Concrete which will not be exposed to freezing, but which is required to be watertight, shall have a water-cement ratio of 0.48 or less if the concrete is exposed to fresh water, or 0.45 or less if exposed to brackish water or sea water. For corrosion protection, reinforced concrete exposed to deicer salts, brackish water or seawater shall have a water-cement ratio of 0.40 or less.
2. Air Content
    a. The air content of concrete that will be exposed to freezing conditions shall be within the limits given in Table 1.

Table 1 Total Air Content for Frost-Resistant Concrete

| **Nominal Maximum Aggregate Size (Inches)** | **Air Content Sever Exposure %** | **Air Content Moderate Exposure %** |
|---|---|---|
| 3/8 | 6.0 – 9.0 | 4.5 – 7.5 |
| ½ | 5.5 – 8.5 | 4.0 – 7.0 |
| ¾ | 4.5 – 7.5 | 3.5 – 6.5 |
| 1 | 4.5 – 7.5 | 3.0 – 6.0 |
| 1 ½ | 4.5 – 7.0 | 3.0 – 6.0 |

*For specified compressive strengths greater than 5000 psi, air content may be reduced 1%.

3. Compressive Strength
    a. All concrete shall develop a minimum compressive strength of 4,000 psi in 28 days unless other strengths are designated on the drawings.
    b. Portland Cement: ASTM C150, Type I, II, III or V.
    c. Aggregates: ASTM C33 or C330.
    d. Water: Potable or free of deleterious substances in amounts harmful to concrete or embedded metals.
    e. Admixtures:
        1) Air-entraining: ASTM C260
        2) Water reducing, retarding, accelerating, high range water reducing: ASTM C494
        3) Pozzolans, fly ash and other mineral admixtures: ASTM C618
        4) Ground granulated blast furnace slag: ASTM C989

## 2.4 REINFORCEMENT AND CONNECTION MATERIALS

A. Provide all reinforcement, accessory and connection materials required. Concrete reinforcement shall be steel bars or welded wire fabric, or a combination thereof.

B. Reinforcing Bars:

1. Deformed Billet-steel: ASTM A615

2. Deformed Rail-steel: ASTM A616

3. Deformed Axle-steel: ASTM A617

4. Deformed Low-alloy steel: ASTM A706

C. Reinforcing Wire:
1. Plain Wire: ASTM A82
2. Deformed Wire: ASTM A496

D. Welded Wire Fabric:
1. Plain Wire: ASTM A185
2. Deformed Wire: ASTM A497

E. Epoxy Coated Reinforcement:
1. Reinforcing Bars: ASTM A775
2. Wires and Fabric: ASTM A884

F. Galvanized Reinforcement:
1. Reinforcing Bars: ASTM A767

G. Inserts and Embedded Metal – All items embedded in concrete shall be of the type required for the intended task, and meet the following standards:
1. Structural steel plates, angles, etc: ASTM A36
2. Proprietary items: In accordance with manufacturers published literature
3. Welded studs: AWS D1.1
4. Finishes (as required):
    a. Shop primer: Manufacturers' standards
    b. Hot-dipped galvanized: ASTM A152
    c. Zinc-rich coating: MIL-P-2135 self-curing, one component, sacrificial
    d. Cadmium coating: Manufacturers' recommendations

H. Joint Sealant and Joint Gaskets:
1. Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets: ASTM C443.
2. External Sealing Bands for Noncircular Sewer, Storm Drain, and Culvert Pipe: ASTM C877.
3. Joints for Concrete Pipe, Manholes, and Manufactured Box Sections Using Preformed Flexible Joint Sealants: ASTM C990.
4. Specification for Elastomeric Joint Sealants: ASTM C920.

I. Pipe Entry Connectors:
   1. Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals: ASTM C923.

J. Grout:
   1. Cement grout: Portland cement with enough water for the required strength and sand for proper consistency. May contain mineral or chemical admixtures if approved by Owner's representative.
   2. Non-shrink grout: Premixed, packaged expansive and non-expansive shrink-resistant grout.

## 2.5 FABRICATION

A. Forms for manufacturing precast concrete products shall be of the type and design consistent with industry standards. They should be capable of consistently providing uniform products and dimensions. Forms shall be constructed so that the forces and vibrations to which the forms will be subjected can cause no product damage.
   1. Forms shall be cleaned of concrete build-up after each use.
   2. Form release agents shall not be allowed to build up on the form casting surfaces.

B. Reinforcement

   1. Cages of reinforcement shall be fabricated either by tying the bars, wires or welded wire fabric into rigid assemblies or by welding where permissible in accordance with AWS D1.4. Reinforcing shall be positioned as specified by the design and so that the concrete cover conforms to requirements. The tolerance on concrete cover shall be one-third of that specified but not more than 1/2 in. Concrete cover shall not be less than 1/2 in. Positive means shall be taken to assure that the reinforcement does not move significantly during the casting operations.

C. Embedded Items

   1. Embedded items shall be positioned at locations specified in the design documents. Inserts, plates, weldments, lifting devices and other items to be imbedded in precast concrete products shall be held rigidly in place so that they do not move significantly during casting operations.

D. Placing Concrete

   1. Concrete shall be deposited into forms as near to its final location as practical. The free fall of the concrete shall be kept to a minimum. Concrete shall be consolidated in such a manner that segregation of the concrete is minimized and honeycombed areas are kept to a minimum. Vibrators used to consolidate concrete shall have frequencies and amplitudes sufficient to produce well consolidated concrete.
   2. Cold Weather Requirements - Recommendations for cold weather concreting are given in detail in Cold Weather Concreting reported by ACI Committee 306.

a. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather.
b. All concrete materials and all reinforcement, forms, fillers, and ground with which concrete is to come in contact shall be free from frost.
c. Frozen materials or materials containing ice shall not be used.
d. In cold weather the temperature of concrete at the time of placing shall not be below 45° F. Concrete that freezes before its compressive strength reaches 500 psi shall be discarded.

3. Hot Weather Requirements - Recommendations for hot weather concreting are given in detail in Hot Weather Concreting reported by ACI Committee 305.
   a. During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure. The temperature of concrete at the time of placing shall not exceed 90° F.

E. Curing

Provide curing by one of the following methods:

1. Curing by Moisture Retention - Moisture shall be prevented from evaporating from exposed surfaces until adequate strength for stripping (Article 2.6, paragraph F) is reached by one of the following methods:
   a. Cover with polyethylene sheets a minimum of 6 mils thick.
   b. Cover with burlap or other absorptive material and keep continually moist.
   c. Use of a membrane-curing compound applied at a rate not to exceed 200 sq. ft. per gallon, or per manufacturers' recommendations.
2. Surfaces that will be exposed to weather during service shall be cured as above a minimum of 3 days. Forms shall be considered effective in preventing evaporation from the contact surfaces. If air temperature is below 50°F the curing period shall be extended.
3. Curing with Heat and Moisture
   a. Concrete shall not be subjected to steam or hot air until after the concrete has attained its initial set. Steam, if used, shall be applied within a suitable enclosure, which permits free circulation of the steam. If hot air is used for curing, precautions shall be taken to prevent moisture loss from the concrete. The temperature of the concrete shall not be permitted to exceed 160° F. These requirements do not apply to products cured with steam under pressure in an autoclave.

F. Stripping Products from Forms

1. Products shall not be removed from the forms until the concrete reaches the compressive strength for stripping required by the design. If no such requirement exists, products may be removed from the forms after the final set of concrete provided that stripping damage is minimal.

G. Shipping Products

1. Products shall not be shipped until they are at least 5 days old, unless it can be shown that the concrete strength has reached at least 75% of the specified 28-day strength, or that damage will not be caused which will impair the performance of the product.

## 2.6 SOURCE QUALITY CONTROL

A. Fabricate units in accordance with ACI 318 and the National Precast Concrete Association's Quality Control Manual for Precast Plants.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Site Access

1. General contractor shall be responsible for providing adequate access to the site to facilitate hauling, storage and proper handling of the precast concrete products.

B. Installation

1. Precast concrete products shall be installed to the lines and grades shown in the contract documents or otherwise specified.
2. Products shall be lifted by suitable lifting devices at points provided by the precast concrete producer.
3. Products shall be installed per the precast concrete producer's recommendation.

C. Water tightness

1. Where water tightness is a necessary performance characteristic of the precast concrete product's end use, watertight joints, connectors and inserts should be used to ensure the integrity of the entire system.

## 3.2 FIELD QUALITY CONTROL

A. Site tests - when testing is required for an underground product, one of the following methods need to be followed:

1. Vacuum testing prior to backfill according to ASTM C1244.
2. Water testing according to contract documents and precast concrete producer's recommendations.

END OF SECTION 034100

# SECTION 042000 – UNIT MASONRY

## PART 1 - GENERAL

### 1.1 DESCRIPTION

This section specifies requirements for construction of masonry unit screen walls.

### 1.2 RELATED WORK

A. Mortars and grouts: Section 04100, Mortar and Grout.

B. Sealants and sealant installation: Section 079200, Joint Sealants.

C. Color and texture of masonry units: By Owner.

### 1.3 SUBMITTALS

A. Submit in accordance with Section 013323, Shop drawings, Product Data and Samples.

A. Samples:

1. Face brick, sample panel, 200 mm by 400 mm (8 inches by 16 inches,) showing full color range and texture of bricks, bond, and proposed mortar joints.
2. Concrete masonry units, when exposed in finish work.
3. Anchors, and ties, one each and joint reinforcing 1200 mm (48 inches) long.

B. Shop Drawings:

1. Special masonry shapes.
2. Drawings, showing reinforcement, applicable dimensions and methods of hanging soffit or lintel masonry and reinforcing masonry for embedment of anchors for hung fixtures.
3. Show Drawings: Submit shop drawings for fabrication, bending, and placement of reinforcing bars. Comply with ACI 315. Show bar schedules, diagrams of bent bars, stirrup spacing, lateral ties and other arrangements and assemblies as required for fabrication and placement of reinforcement for unit masonry work.

C. Certificates:

1. Certificates signed by manufacturer, including name and address of contractor, project location, and the quantity, and date or dates of shipment of delivery to which certificate applies.
2. Indicating that the following items meet specification requirements:
    a. Face brick.
    b. Solid and load-bearing concrete masonry units, including fire-resistant rated units.

3. Testing laboratories facilities and qualification of its principals and key personnel to perform tests specified.

D. Manufacturer’s Literature and Data:

1. Anchors, ties, and reinforcement.
2. Shear keys.
3. Reinforcing bars.

## 1.4 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM):

A951-06…………….Steel Wire for Masonry Joint Reinforcement

A615………………..Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

C90-11……….......Load-Bearing Concrete Masonry Units

C216-10……………..Facing Brick (Solid Masonry Units Made From Clay or Shale)

C476-10……………..Standard Specification for Grout for Masonry

C612-10……………..Mineral Fiber Block and Board Thermal Insulation

C744-11……………..Prefaced Concrete and Calcium Silicate Masonry Units

D1056-07……………Flexible Cellular Materials – Sponge or Expanded Rubber

D2000-08……......Rubber Products in Automotive Applications

D2240-05(R2010). …Rubber Property – Durometer Hardness

D3574-08……………Flexible Cellular Materials-Slab, Bonded, and Molded Urethane Foams

F1667-11…………….Fasteners: Nails, Spikes and Staples

C. Masonry Industry Council

Hot and Cold Weather Masonry Construction Manul-98 (R2000).

D. American Welding Society (AWS):

D1.4-11 Structural Welding Code – Reinforcing Steel

E. Federal Specification (FS):

FF-S-107C-00…………..Screws, Tapping and Drive

F. Brick Industry Association – Technical Notes on Brick Construction (BIA):

11-2001…………………..Guide Specifications for Brick Masonry, Part 1

11A-1988………………...Guide Specifications for Brick Masonry, Part II

11B-1988…………………Guide Specifications for Brick Masonry, Part III Execution

11C-1998…………………Guide Specification for Brick Masonry Engineered Brick Masonry, Part IV

11D-1988 Guide Specifications for Brick Masonry Engineered Brick Masonry, Part IV continued.

G. Masonry Standards Joint Committee; Specification for Masonry Structures TMS 602-08/ACI 530.1-08/ASCE 6-08 (2008 MSJC Book Version TMS-0402-08).

## PART 2 - PRODUCTS

### 2.1 BRICK

A. Face Brick:

1. ASTM C216, Grade SW, Type FBS.
2. Brick when tested in accordance with ASTM C67: Classified slightly efflorescent or better.
3. Size:
    a. Modular

### 2.2 CONCRETE MASONRY UNITS

A. Hollow and Solid Load-Bearing Concrete Masonry Units: ASTM C90.

1. Unit Weight: // Normal weights// medium weight// lightweight//.
2. Fire rated units for fire rated partitions.
3. Sizes: Modular.
4. For molded faces used as a finished surface, use concrete masonry units with uniform fine to medium surface texture unless specified otherwise.
5. Customized units:
    a. Sound-Absorbing Units:
        1) Vertical slots in face to core areas.
        2) Acoustical absorption insert: Mineral fiber and metal septum, providing unit with NRC rating of 0.70.
    b. Split-face Units:
        1) Split-Rib Units: Rib shapes as shown.

2) Ground Face Units.

B. Concrete Brick: ASTM C55.

## 2.3 ANCHORS, TIES, AND REINFORCEMENT

A. Steel Reinforcing Bars: ASTM A615M, deformed bars, grade as shown

B. Joint Reinforcement:

1. Form from wire complying with ASTM A951.

2. Galvanized after fabrication.

3. Width of joint reinforcement 40mm (0.16 inches) less than nominal width of masonry wall or partition.

4. Cross wires welded to longitudinal wires.

5. Joint reinforcement at least 3000 mm (10 feet) in length.

6. Joint reinforcement in rolls is not acceptable.

7. Joint reinforcement that is crimped to form drip is not acceptable.

8. Maximum spacing of cross wires 400 mm (16 inch) to longitudinal wires.

9. Ladder Design:
   a. Longitudinal wires deformed 4 mm (0.16 inch) 5 mm (0.20 inch) diameter wire.
   b. Cross wires 2.6 mm (0.10 inch) 4 mm (0.16 inch nominal) diameter.

10. Trussed Design:
    a. Longitudinal and cross wires not less than 4 mm (0.16 inch nominal) diameter.
    b. Longitudinal wires deformed.

11. Multiple Wythes and Cavity wall ties:
    a. Longitudinal wires 4 mm (0.16 inch), two in each wythe with ladder truss wires 4 mm (0.16 inch) overlay, welded to each longitudinal wire.
    b. Longitudinal wires 4 mm (0.16 inch) with U shape 4 mm (0.16 inch) rectangular ties extending into other wythe not less than 75 mm (3 inches) spaced 400 mm o.c. (16 inches). Adjustable type with U shape tie designed to receive 4 mm (0.16 inch) pintle projecting into other wythe 75 mm (3 inches min).
    c. Adjustable Veneer Anchor for Frame Walls:
       1) Two piece, adjustable anchor and tie.
       2) Anchor and tie may be either type; use only one type throughout.
       3) Loop Type:
          a) Anchor: Screw-on galvanized steel anchor strap 2.75 mm (0.11 inch) by 19 mm (3/4 inch) wide by 225 mm (9 inches) long, with 9 mm

(0.25 inch) offset and 100 mm (4 inch) adjustment. Provide 5 mm (0.20 inch) hole at each end for fasteners.

b) Ties: Triangular tie, fabricated of 5 mm (0.20 inch) diameter galvanized cold drawn steel wire. Ties long enough to engage the anchor and be embedded not less than 50 mm (2 inches into the bed joint of the masonry veneer.

## 2.4 PREFORMED COMPRESSIBLE JOINT FILLER

A. Thickness and depth to fill the joint as specified.

B. Closed Cell Neoprene: ASTM D1056, Type 2, Class A, Grade 1, B2F1.

C. Non-Combustible Type: ASTM C612, Class 5, 1800 degrees F.

## 2.5 ACCESSORIES

A. Weep Hole Wicks: Glass fiber ropes, 10 mm (3/8 inch) minimum diameter, 300 mm (12 inches) long.

B. Box Board:

1. Mineral Fiber Board: ASTM C612, Class 1.
2. 25 mm (1 inch) thickness.
3. Other spacing material having similar characteristics may be used subject to the Resident Engineer’s approval.

C. Masonry Cleaner:

1. Detergent type cleaner selected for each type masonry used.
2. Acid cleaners are not acceptable.
3. Use soapless type specially prepared for cleaning brick or concrete masonry as appropriate.

# PART 3 - EXECUTION

## 3.1 JOB CONDITIONS

A. Protection:

1. Cover tops of walls with nonstaining waterproof covering, when work is not in progress. Secure to prevent wind blow off.

2. On new work protect base of wall from mud, dirt, mortar droppings, and other materials that will stain face, until final landscaping or other site work is completed.

B. Cold Weather Protection:

1. Masonry may be laid in freezing weather when methods of protection are utilized.
2. Comply with MSJC and “Hot and Cold Weather Masonry Construction Manual”.

## 3.2 CONSTRUCTION TOLERANCES

A. Lay masonry units plumb, level and true to line within the tolerances as per MSJC requirements and as follows:

B. Maximum variation from plumb:

1. In 3000 mm (10 feet) – 6 mm (1/4 inch).
2. In 6000 mm (20 feet) – 10 mm (3/8 inch).
3. In 12 000 mm (40 feet) or more – 13 mm (1/2 inch).

C. Maximum variation from level:

1. In any bay or up to 600 mm (20 feet) – 6 mm (1/4 inch).
2. In 12 000 mm (40 feet) or more – 13 mm (1/2 inch).

D. Maximum variation from linear building lines:
1. In any bay or up to 6000 mm (20 feet) – 13 mm (1/2 inch).
2. In 12 000 mm (40 feet) or more – 19 mm (3/4 inch).

E. Maximum variation in cross-sectional dimensions of columns and thickness of walls from dimensions shown:

1. Minus 6 mm (1/4 inch).
2. Plus 13 mm (1/2 inch).

F. Maximum variation in prepared opening dimensions:

1. Accurate to minus 0 mm (0 inch).
2. Plus 6 mm (1.4 inch).

## 3.3 INSTALLATION GENERAL

A. Keep finish work free from mortar smears or spatters, and leave neat and clean.

B. Anchor masonry as specified in Paragraph, ANCHORAGE.

C. Wall Openings:
1. Fill hollow metal frames built into masonry walls and partitions solid with mortar as laying of masonry progresses.

2. If items are not available when walls are built, prepare openings for subsequent installation.

D. Tooling Joints:

1. Do not tool until mortar has stiffened enough to retain thumb print when thumb is pressed against mortar.
2. Tool while mortar is soft enough to be compressed into joints and not raked out.
3. Finish joints in exterior face masonry work with a jointing tool, and provide smooth, water-tight concave joint unless specified otherwise.
4. Tool Exposed interior joints in finish work concave unless specified otherwise.

## 3.4 ANCHORAGE

A. Masonry Facing to Backup and Cavity Wall Ties:

1. Use individual ties for new York.
2. Stagger ties in alternate courses, and space at 400 mm (16 inches) maximum vertically, and 60 mm (2 feet) horizontally.
3. At openings, provide additional ties spaced not more than 900 mm (3 feet) apart vertically around perimeter of opening, and within 300 mm (12 inches) from edge of opening.
4. Anchor new masonry facing to existing masonry with corrugated wall ties spaced at 400 mm (16 inch) maximum vertical intervals and at every second masonry unit horizontally. Fasten ties to masonry with masonry nails.
5. Option: Use joint reinforcing for multiple wythes and cavity wall ties spaced not more than 400 mm (16 inches) vertically.
6. Tie interior and exterior wythes of reinforced masonry walls together with individual ties. Provide ties at intervals not to exceed 600 mm (24 inches) on center horizontally, and 400 mm (16 inches) on center vertically. Lay ties in the same line vertically in order to facilitate vibrating of the grout pours.

## 3.5 REINFORCEMENT

A. Joint Reinforcement

1. Use as joint reinforcement in CMU wythe of combination brick and CMU, cavity walls, and single wythe concrete masonry unit walls or partitions.
2. Reinforcing may be used in lieu of individual ties for anchoring brick facing to CMU backup in exterior masonry walls.
3. Brick veneer over frame backing walls does not require joint reinforcement.
4. Locate joint reinforcement in mortar joints at 400 mm (16 inch) maximum vertical intervals.
5. Additional joint reinforcement is required in mortar joints at both 200 mm (18 inches) and 400 (16 inches) above and below windows, doors, louvers and similar openings in masonry, except where other type anchors are required for anchorage of masonry to concrete structure.
6. Joint reinforcement is required in every other course of stack bond CMU masonry.

7. Wherever brick masonry is backed up with stacked bond masonry, joint reinforcement is required in every other course of CMU backup, and is corresponding joint of facing brick.

B. Steel Reinforcing Bars:

1. Install in cells of hollow masonry units where required for vertical reinforcement and in bond beam units for lintels and bond beam horizontal reinforcement. Install in wall cavities of reinforced masonry walls where shown.

2. Use grade 60 bars if not specified otherwise.

3. Bond Beams:
   a. Form Bond beams of load-bearing concrete masonry unites filled with ASTM C476 grout and reinforced with 2-#15m (#5) reinforcing steel unless shown otherwise. Do not cut reinforcement.
   b. Break bond beams only at expansion joints and at control joints, if shown.

4. Stack Bond:
   a. Locate additional joint reinforcement in vertical and horizontal joints as shown.
   b. Anchor vertical reinforcement into the foundation or wall or bond beam below and hold in place.
   c. Provide temporary bracing for wall over 8 ft. tall until permanent horizontal bracing is completed.

5. Grout openings:
   a. Leave cleanout holes in double wythe walls during construction by omitting units at the base of one side of the wall.
   b. Locate 75 mm x 75 mm (3 in. x 3in.) min. clean-out holes at location of vertical reinforcement.
   c. Keep grout space clean of mortar accumulation and sand debris. Clean the grout space every day using a high pressure jet stream of water, or compressed air, or industrial vacuum, or by laying wood strips on the metal ties as the wall is built. If wood strips are used, lift strips with wires as the wall progresses and before placing each succeeding course of wall ties.

## 3.6 BRICK EXPANSION AND CMU CONTROL JOINTS.

A. Provide brick expansion (BEJ) and CMU control (CJ) joints where shown on drawings.

B. Keep joint free of mortar and other debris.

C. Where joints occur in masonry walls.

1. Install preformed compressible joint filler in brick wythe.
2. Install cross shaped shear keys in concrete masonry unit wythe with preformed compressible joint filler on each side of shear key unless otherwise specified.
3. Install filler, backer rod, and sealant on exposed faces.

D. Use standard notched concrete masonry units (sash blocks made in full and half-length units where shear keys are used to create a continuous vertical joint.

E. Interrupt steel joint reinforcement at expansion and control joins unless otherwise shown.

F. Fill opening in exposed face of expansion and control joints with sealant as specified in Section 079200, Joint Sealants.

G. Where exposed in finish work, cut back filler material in the joint enough to allow for the joint to be filled with sealant material specified in Section 07 92 00, JOINT SEALANTS.

## 3.7 BRICKWORK

A. Lay clay brick in accordance with BIA Technical Note 11 series.

B. Laying:

1. Lay brick in running bond with course of masonry bonded at corners unless shown otherwise. Match bond of existing building on alterations and additions.
2. Maintain bond pattern throughout.
3. Do not use brick smaller than half-brick at any angle, corner, break or jamb.
4. Where length of cut brick is greater than one half but less than a whole brick, maintain the vertical joint location of such units.
5. Lay exposed brickwork joints symmetrical about center lines of openings.
6. Do not structural bond multi wythe brick walls unless shown.
7. Before starting work, lay facing brick on foundation wall and adjust bond to openings, angles, and corners.
8. Lay brick for sills with wash and drip.
9. Build solid brickwork as required for anchorage of items.

C. Joints:

1. Exterior and interior joint widths: Lay for three equal joints in 200 mm (either inches) vertically, unless shown otherwise.
2. Rake joints for pointing with colored mortar when colored mortar is not full depth.

D. Weep Holes:

1. Install weep holes at 600 mm (24 inches) on center in bottom of vertical joints of exterior masonry veneer or cavity wall facing over foundations, bond beams, and other water stops in the wall.
2. Form weep holes using wicks made of mineral fiber insulation strips turned up 200 mm (8 inches) in cavity. Anchor top of strip to backup to securely hold in place.
3. Install sand or pea gravel in cavity approximately 75 mm (3 inches) high between weep holes.

E. Cavity Type Exterior Walls:

1. Keep air space clean or mortar accumulations and debris.

a. Clean cavity by use of hard rubber, wood or metal channel strips having soft material on side contacting wythes.
b. Lift strips with wires before placing next courses of horizontal joint reinforcement or individual ties or adjustable cavity wall ties.

2. For each lift lay two courses of concrete masonry units, followed by six courses of brick facing.
3. Lay the interior wythe of the masonry wall full height where dampproofing is required on cavity face. Coordinate to install dampproofing prior to laying outer wythe.

## 3.8 CONCRETE MASONRY

A. Kind and Users:

1. Provide special concrete masonry shapes as required, including lintel and bond beam units, sash units, and corner units. Use solid concrete masonry units, where full units cannot be used, or where needed for anchorage of accessories.
2. Provide solid load-being concrete masonry units or grout the cell of hollow units at jambs of openings in walls, where structural members impose loads directly on concrete masonry, and where shown.
3. Provide rounded corner (bullnose) shapes at opening jambs in exposed work and at exterior corners.
4. Do not use brick jambs in exposed finish work.
5. Use concrete building brick only as filler in backup material where not exposed.
6. Masonry assemblies shall meet the required for resistance in fire rated partitions of type and construction that will provide fire rating as shown.
   a. Set units according to applicable requirements specified for concrete masonry units.
   b. Use brick or load-bearing structural clay tile units, with cores set vertically, and filled with grout where structural members impose concentrated load directly on structural clay tile masonry.

B. Laying:

1. Lay concrete masonry units with 10 mm (3/8 inch) joints, with a bond overlap of not less than ¼ of the unit length, except where stack bond is required.
2. Do not wet concrete masonry units before laying.
3. Bond external corners of partitions by over lapping alternate courses.
4. Lay first course in a full mortar bed.
5. Set anchorage items as work progress.
6. Where ends of anchors, bolts, and other embedded items, project into voids of units, completely fill such voids with mortar or grout.
7. Provide a 6 mm (1/4 inch) open joint for caulking between existing construction, exterior walls, concrete work, and abutting masonry partitions.
8. Lay concrete masonry units with full face shell mortar beds and fill head joint beds for depth equivalent to face shell thickness.
9. Lay concrete masonry units so that cores of units, that are to be filled with grout, are vertically continuous with joints or cross webs of such cores completely filled with mortar. Unobstructed core opening not less than 50 mm (2 inches) by 75 mm (3inches).

10. Do not wedge the masonry against the steel reinforcing. Minimum 13 mm (1/2 inch) clear distance between reinforcing and masonry units.
11. Install deformed reinforcing bars of sizes shown.
12. Steel reinforcement, at time of placement, free of loose flaky rust, mud, oil, or other coatings that will destroy or reduce bond.
13. Steel reinforcement in place before grouting.
14. Minimum clear distance between parallel bars: One bar diameter.
15. Hold vertical steel reinforcement in place by centering clips, caging devices, tie wire, or other approved methods, vertically at spacings noted.
16. Support vertical bars near each end and at intermediate intervals not exceeding 192 bar diameters.
17. Reinforcement shall be fully encased by grout or concrete.
18. Splice reinforcement or attach reinforcement to dowels by placing in contact and secured or by placing the reinforcement within 1/5 of the required bar splice length.
19. Stagger splices in adjacent horizontal reinforcing bars. Lap reinforcing bars at splices a minimum of 40 bar diameters.
20. Grout cells of concrete masonry units, containing the reinforcing bars, solid as specified under grouting.
21. Cavity and joint horizontal reinforcement may be placed as the masonry work progresses.
22. Rake joints 6 to 10 mm (1/4 to 3/8 inch) deep for pointing with colored mortar when colored mortar is not full depth.

## 3.9 POINTING

A. Fill joints with pointing mortar using rubber float trowel to rub mortar solidly into raked joints.

B. Wipe off excess mortar from joints of glazed masonry units with dry cloth.

C. Finish exposed joints in finish work with a jointing tool to provide a smooth concave joint unless specified otherwise.

D. At joints with existing work match existing joint.

## 3.10 GROUTING

A. Preparation:

1. Clean grout space of mortar droppings before placing grout.
2. Close cleanouts.
3. Install vertical solid masonry dams across grout space for full height of wall at intervals of not more than 9000 mm (30 feet). Do not bond dam units into wythes as masonry headers.
4. Verify reinforcing bars are in cells of units or between wythes as shown.

B. Placing:

1. Place grout by hand bucket, concrete hopper, or grout pump.
2. Consolidate each lift of grout after free water has disappeared but before plasticity is lost.

3. Do not slush with mortar or use mortar with grout.
4. Interruptions:
    a. When grouting must be stopped for more than an hour, top off grout 40 mm (1-1/2 inch) below top of last masonry course.
    b. Grout from dam to dam on high lift method.
    c. A longitudinal run of masonry may be stopped off only by raking back one-half a masonry unit length in each course and stopping grout 100 mm (4 inches) back of rake on low loft method.

C. Puddling Method:

1. Double wythe masonry constructed grouted in lifts not to exceed 300 mm (12 inches) or less than 50 mm (2 inches) wide.
2. Consolidate by puddling with a grout stick during and immediately after placing.
3. Grout the cores of concrete masonry units containing the reinforcing bars solid as the masonry work progresses.

D. Low Life Method:

1. Construct masonry to a height of 1.5 m (5 ft) maximum before grouting.
2. Grout in one continuous operation and consolidate grout by mechanical vibration and reconsolidate after initial water loss and settlement has occurred.

E. High Lift Method:

1. Do not pour grout until masonry wall has properly cured a minimum of 4 hours.
2. Place grout in lifts not exceeding 1.5 m (5 ft).
3. Exception:

    Where the following conditions are met, place grout in lifts not exceeding 3.86 m (12.67 ft).

    a. The masonry has cured for at least 4 hours.
    b. The grout slump is maintained between 254 and 279 mm (10 and 11 in).
    c. No intermediate reinforced bond beams are placed between the top and the bottom of the pour height.
4. When vibrating succeeding lifts, extend vibrator 300 to 450 mm (12 to 18 inches) into the preceding lift to close any shrinkage cracks or separation from the masonry units.

## 3.11 PLACING REINFORCEMENT

A. General: Clean reinforcement of loose rust, mill scale, earth, ice or other materials which will reduce bond to mortar or grout. Do not use reinforcement bars with kinks or bends not shown on the Contract Drawings or final shop drawings, or bars with reduced cross-section due to excessive rusting or other causes.

B. Position reinforcement accurately at the spacing indicated. Support and secure vertical bars against displacement. Horizontal reinforcement may be placed as the masonry work progresses.

Where vertical bars are shown in close proximity, provide a clear distance between bars of not less than nominal bar diameter or 25 mm (1 inch), whichever is greater.

C. For columns, piers and pilasters, provide a clear distance between vertical bars as indicated, but not less than 1 ½ times the nominal bar diameter or 38 mm (1-1/2 inches), whichever is greater. Provide lateral ties as indicated.

D. Splice reinforcement bars where shown; do not splice at other places unless accepted by the Resident Engineer. Provide lapped splices, unless otherwise indicated. In splicing vertical bars or attaching to dowels, lap ends, place in contact and wire tie.

E. Provide not less than minimum lap as indicated on shop drawings, or it not indicated, as required by governing code.

F. Weld splices where indicated. Comply with the requirements of AWS D1.4 for welding materials and procedures.

G. Embed metal ties in mortar joints as work progresses, with a minimum mortar cover of 15 mm (5/8 inch) on exterior face of walls and 13 mm (1/2 inch) at other locations.

H. Embed prefabricated horizontal joint reinforcement as the work progresses, with a minimum cover of 15 mm (5/8 inch) on exterior face of walls and 13 mm (1/2 inch) at other locations. Lap joint reinforcement not less than 150 mm (6 inches) at ends. Use prefabricated “L” and “T” sections to provide continuity at corners and intersections. Cut and bend joint reinforcement as recommended by manufacturer for continuity at returns, offsets, column fireproofing, pipe enclosures and other special conditions.

I. Anchoring: Anchor reinforced masonry work to supporting structure as indicated.

J. Anchor reinforced masonry walls to non-reinforced masonry where they intersect.

## 3.12 INSTALLATION OF REINFORCED CONCRETE UNIT MASONRY

A. Do not wet concrete masonry units (CMU).

B. Lay CMU units with full-face shell mortar beds. Fill vertical head joints (end joints between units) solidly with mortar from face of unit to a distance behind face equal to not less than the thickness of longitudinal face shells. Solidly bed cross-webs of starting courses in mortar. Maintain head and bed joint widths shown, or if not shown, provide 10 mm (3/8 inch) joints.

C. Where solid CMU units are shown, lay with full mortar head and bed joints.

D. Walls:

1. Pattern Bond: Lay CMU wall units in ½-running bond with vertical joints in each course centered on units in courses above and below, unless otherwise indicated. Bond and interlock each course at corners and intersections. Use special-shaped units where shown, and as required for corners, jambs, sash, control joints, lintels, bond beams and other special conditions.

2. Maintain vertical continuity of core or cell cavities, which are to be reinforced and grouted, to provide minimum clear dimension indicated and to provide minimum clearance and grout coverage for vertical reinforcement bars. Keep cavities free of mortar. Solidly bed webs in mortar where adjacent to reinforced cores or cells.
3. Where horizontal reinforced beams (bond beams) are shown, use special units or modify regular units to allow for placement of continuous horizontal reinforcement bars. Place small mesh expanded metal lath or wire screening in mortar joints under bond beam courses over cores or cells of non-reinforced vertical cells, or provide units with solid bottoms.

E. Columns, Piers and Pilasters:

1. Use CMU units of the size, shape and number of vertical core spaces shown. If not shown, use units which provide minimum clearances and grout coverage for number and size of vertical reinforcement bars shown.
2. Provide pattern bond shown, or it not shown, alternate head joints in vertical alignment.
3. Where bonded pilaster construction is shown, lay wall and pilaster units together to maximum pour height specified.

F. Grouting:

1. Use “Fine Grout” per ASTM C476 for filling spaces less than 100 mm (4 inches) in one or both horizontal directions.
2. Use “Coarse Grout” per ASTM C476 for filling 100 mm (4 inch) spaces or larger in both horizontal directions.
3. Grouting Technique: At the Contractor’s option, use either low-lift or high-lift grouting techniques subject to requirements which follow.

G. Low-Lift Grouting:

1. Provide minimum clear dimension of 50 mm (2 inches) and clear area of 5160 $mm^2$ (8 square inches) in vertical cores to be grouted.
2. Place vertical reinforcement prior to grouting of CMU. Extend above elevation of maximum pour height as required for splicing. Support in position at vertical intervals not exceeding 192 bar diameters nor 3 m (10 feet).
3. Lay CMU to maximum pour height. Do not exceed 1.5 m (5 foot) height, or if bond beam occurs below 1.5 m (5 foot) height, stop pour 38 mm (1-1/2 in) below top of bond beam.
4. Pour Beams: Stop grout in vertical cells 38 mm (1-1/2 inches) below bond beam course. Place horizontal reinforcement in bond beams; lap at corners and intersections as shown. Place grout in bond beam course before filling vertical cores above bond beam.

H. High-Life Grouting:

1. Do not use high-lift grouting technique for grouting of CMU unless minimum cavity dimension and area is 75 mm (3 inches) and 6450 $mm^2$ (10 square inches), respectively.
2. Provide cleanout holes in first course at all vertical cells which are to be filled with grout.
3. Use units with one face shell removed and provide temporary supports for units above, or use header units with concrete brick supports, or cut opening in one face shell.
4. Construct masonry to full height of maximum grout pour specified, prior to placing grout.

5. Limit grout lifts to a maximum height of 1.5 m (5 feet) and grout pour to a maximum height of 7.3 m (24 feet), for singly wythe hollow concrete masonry walls, unless otherwise indicated.
6. Place vertical reinforcement before grouting. Place before or after laying masonry units, as required by job conditions. Tie vertical reinforcement to dowels at base of masonry where shown and thread CMU over or around reinforcement. Support vertical reinforcement at intervals not exceeding 192 bar diameters nor 3 m (10 feet).
7. Where individual bars are placed after laying masonry, place wire loops extending into cells as masonry is laid and loosed before mortar sets. After insertion of reinforcement bar, pull loops and bar to proper position and tie free ends.
8. Where reinforcement is prefabricated into cage units before placing, fabricate units with vertical reinforcement bars and lateral ties of the size and spacing indicated.
9. Place horizontal beam reinforcement as the masonry units are laid.
10. Embed lateral tie reinforcement in mortar joints where indicated. Place as masonry units are laid, at vertical spacing shown.
11. Where lateral ties are shown in contact with vertical reinforcement bars, embed additional lateral tie reinforcement in mortar joints. Place as shown, or if not shown, provide as required to prevent grout blowout or rupture of CMU face shells, but provide not less than 4.1 mm diameter (8 gage) wire ties spaced 400 mm (16 inches) o.c. for members with 500 mm (20 inches) or less side dimensions, and 200 mm (8 inches) o.c. for members with side dimensions exceeding 500 mm (20 inches).
12. Preparation of Grout Spaces: Prior to grouting, inspect and clean grout spaces. Remove dust, dirt, mortar droppings, loose pieces of masonry and other foreign materials from grout spaces. Clean reinforcement and adjust to proper position. Clean top surface of structural members supporting masonry to ensure bond. After final cleaning and inspection, close cleanout holes and brace closures to resist grout pressures.
13. Do not place grout until entire heights of masonry to be grouted has attained sufficient strength to resist displacement of masonry units and breaking of mortar bond. Install shores and bracing, if required, before starting grouting operations.
14. Place grout by pumping into grout spaces unless alternate methods are acceptable to the Resident Engineer.
15. Limit grout pours to sections which can be completed in one working day with not more than one hour interruption of pouring operation. Place grout in lifts which do not exceed 1.5 m (5 feet). Allow not less than 30 minutes, nor more than one hour between lifts of a given pour. Mechanically consolidate each grout lift during pouring operation.
16. Place grout in lintels or beams over openings in one continuous pour.
17. Where bond beam occurs more than one course below top of pour, fill bond beam course to within 25 mm (1 inch) of vertically reinforced cavities, during construction of masonry.
18. When more than one pour is required to complete a given section of masonry, extend reinforcement beyond masonry as required for splicing. Pour grout to within 38 mm (1-1/2 inches) of top course of first pour. After grouted masonry is cured, lay masonry units and place reinforcement for second pour section before grouting. Repeat sequence if more pours are required.

## 3.13 CLEANING AND REPAIR

A. General:

1. Clean exposed masonry surfaces on completion.
2. Protect adjoining construction materials and landscaping during cleaning operations.
3. Cut out defective exposed new joints to depth of approximately 19 mm (3/4 inch) and repoint.
4. Remove mortar droppings and other foreign substances from wall surfaces.

B. Brickwork:

1. First wet surfaces with clean water, then wash down with a solution of soapless detergent. Do not use muriatic acid.
2. Brush with stiff fiber brushes while washing, and immediately thereafter hose down with clean water.
3. Free clean surfaces of traces of detergent, foreign streaks, or stains of any nature.

C. Concrete Masonry Units:

1. Immediately following setting, brush exposed surfaces free of mortar or other foreign matter.
2. Allow mud to dry before brushing.

END OF SECTION 042000

# SECTION 050940

# POST-INSTALLED ANCHORS

## SECTION 050940 – POST-INSTALLED ANCHORS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the furnishing and installation of post-installed anchors.

### 1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following pertinent provisions:

1. ASTM:
    a. A36 - Carbon Structural Steel.
    b. A198 - Steel Bolting Materials for High-Temperature Service.
    c. A240 - Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    d. A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
    e. A510 - General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
    f. A563 - Carbon and Alloy Steel Nuts.
    g. B633 - Electrodeposited Coatings of Zinc on Iron and Steel.
    h. E488 - Strength of Anchors in Concrete and Masonry Elements.
    i. E1512 - Testing Bond Performance of Bonded Anchors.
    j. F436 - Hardened Steel Washers.
    k. F844 - Washers, Steel, Plain (Flat), Unhardened for General Use.
2. ACI 318-02, Appendix D - Anchoring to Concrete.
3. Michigan Building Code.

### 1.4 SUBMITTALS

A. Product Data: For All Members to be Furnished:

1. Base material being fastened to.
2. Anchor embedment depth in base material.

### 1.5 QUALITY ASSURANCE

A. Installation Personnel Qualifications:

1. Trained and experienced in the type of work being performed.
2. Knowledgeable of the specific manufacturer’s requirements for quality installation of post-installed anchors.

B. Inspection of Post-Installed Anchor Installation: Field instruction and inspection during the installation process by Manufacturer’s authorized field representative shall take place at the discretion of Engineer. The General Contractor may utilize such instruction and inspection at any time without the authorization of Engineer. Any costs which may be associated with such services shall be paid for by the General Contractor.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Post-Installed Anchor Material:
  1. Anchors that resist loads through mechanical friction or keying forces:
    a. Expansion Anchors:
      1) Wedge style anchor.
      2) Capable of sustaining an ultimate load of 6 times the imposed load capacity in unit masonry and 4 times the imposed load capacity in concrete when tested in accordance with ASTM E488.
      3) Hilti Kwik Bolt III; Powers Power-Stud; or equal.
      4) Stainless steel in accordance with ASTM F593.
    b. Sleeve Anchors:
      1) Expanding sleeve style anchor.
      2) Hilti LLC or LSL heavy duty sleeve anchors; Powers Lok/Bolt sleeve anchor; or equal.
      3) Hex, acorn, round or flat head anchor or threaded anchor with hex nut as situation requires or as indicated on the Drawings.
      4) Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
      5) Dry Areas: Mild steel, galvanized in accordance with ASTM B633.
    c. Undercut Anchors:
      1) Expanding sleeve, self-undercutting wedge style anchor.
      2) Hilti HDA Undercut Anchors; Powers Power-Bolt Anchors; or equal.
      3) Hex or flat head anchor or threaded anchor with hex nut as situation requires or as indicated on the Drawings.
      4) Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
  2. Anchors that resist loads through an injectable chemical adhesive:
    a. In Concrete: Hilti HIT HY-150, HIT-ICE, HIT-T2, HIT RE 500 and HSE 2421; Powers Power-Fast; or equal.
    b. Anchored Material: Deformed reinforcing bars as indicated on the Drawings.
    c. Bonding Strength: Tested in accordance with ASTM E1512.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install Post-Installed Anchors:
  1. In strict accordance with the installation instructions supplied by the Manufacturer.
  2. Under the direction and Site supervision of the Manufacturer’s authorized field representative when directed to do so by the Project Engineer.
  3. In drilled out holes of the proper depth and diameter cleaned of dust and debris according to the Manufacturer’s specific installation instructions.

B. Post installed anchors anchored to substrate with an injectable adhesive shall have no load applied until adhesive has properly cured and developed specified strength where cure time shall be as called out in the Manufacturer's literature based on prevailing environmental conditions at the time of installation.

END OF SECTION 050940

# SECTION 055000 - METAL FABRICATIONS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Steel handrail.
   2. Steel framing and supports for mechanical and electrical equipment.
   3. Steel framing and supports for applications where framing and supports are not specified in other Sections.
   4. Shelf angles.
   5. Metal ladders.
   6. Ladder safety cages.
   7. Metal floor plate.
   8. Miscellaneous steel trim.
   9. Metal bollards.
   10. Loose bearing and leveling plates for applications where they are not specified in other Sections.

### 1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

### 1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Metal nosings and treads.
   2. Paint products.
   3. Grout.

B. Shop Drawings: Show fabrication and installation details. For all assemblies.

## 1.5 INFORMATIONAL SUBMITTALS

A. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

## 1.6 QUALITY ASSURANCE

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

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

## 1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

## PART 2 - PRODUCTS

## 2.1 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666.

D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.

E. Steel Tubing: ASTM A 500/A 500M, cold-formed steel tubing.

F. Steel Pipe: ASTM A 53/A 53M, Standard Weight (Schedule 40) unless otherwise indicated.

G. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

## 2.2 FASTENERS

A. General: Unless otherwise indicated, provide **Type 304** stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
   1. Provide stainless-steel fasteners for fastening nickel silver.
   2. Provide bronze fasteners for fastening bronze.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A with hex nuts, ASTM A 563 flat washers.

C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3 with hex nuts, ASTM A 563, Grade C3 flat washers.

D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593 with hex nuts, ASTM F 594 flat washers.

E. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563 and, where indicated, flat washers.

   1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

F. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.

G. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.

## 2.3 MISCELLANEOUS MATERIALS

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

   1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

C. Water-Based Primer: Emulsion type, anticorrosive primer for mildly corrosive environments that is resistant to flash rusting when applied to cleaned steel, complying with MPI#107 and compatible with topcoat.

D. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

E. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.

F. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

G. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

H. Concrete: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete.

## 2.4 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

## 2.5 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

C. Galvanize miscellaneous framing and supports where indicated.

## 2.6 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

   1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize miscellaneous steel trim.

## 2.7 STEEL WELD PLATES AND ANGLES

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

## 2.8 FINISHES, GENERAL

A. Finish metal fabrications after assembly.

B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

## 2.9 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.

B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.

C. Shop prime iron and steel items **not indicated to be galvanized** unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.

# PART 3 - EXECUTION

## 3.1 INSTALLATION, GENERAL

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

## 3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

B. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.

   1. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates" Article.

C. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" Article.

   1. Grout baseplates of columns supporting steel girders after girders are installed and leveled.

## 3.3 INSTALLING PREFABRICATED BUILDING COLUMNS

A. Install prefabricated building columns to comply with AISC 360, "Specifications for Structural Steel Buildings," and with requirements applicable to listing and labeling for fire-resistance rating indicated.

## 3.4 INSTALLING METAL BOLLARDS

A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.

B. Anchor bollards in concrete. Fill annular space around bollard solidly with nonshrink grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch toward bollard.

C. Fill bollards solidly with concrete, mounding top surface to shed water.

## 3.5 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION 055000

# SECTION 260510 – ELECTRICAL DESIGN AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 SCOPE OF SUPPLY

This section includes design, performance, and technical requirements for Supplier-furnished electrical equipment. The scope of supply shall include the following items:

- Medium voltage switchgear equipment.
- Medium voltage controller equipment.
- Low voltage motor control assemblies.
- Low voltage power distribution equipment, including the following:
    - Low voltage switchboards.
    - Low voltage panelboards.
    - Dry type transformers.

### 1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply are identified as follows:

(Later)

### 1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the Supplier-furnished electrical equipment are as required by Supplier's design, as indicated in Article 16051.2, on the Electrical Design and Equipment Data Sheets included at the end of this section, and as follows:

| | |
|---|---|
| Design ambient temperature | 104° F (40° C) |
| Site elevation | Less than 3,300 ft (1,000 m) |

### 1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

| **Work** | **In Accordance With** |
|---|---|
| All | The latest revisions of the applicable ANSI C37, NEMA ICS2, IEC, and UL standards |

## 1.5 MATERIALS

The following materials shall be used:

| **Component** | **Material** |
|---|---|
| | |

## 1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

| **Component** | **Manufacturer** |
|---|---|
| Medium voltage switchgear equipment | Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company |
| Medium voltage controller equipment | Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc, Powell Electrical Manufacturing Company |
| Protective relays | ABB Power T&D, Basler Electric, Beckwith Electric, GE, GE - Multilin, Siemens Energy & Automation |
| Low voltage switchgear (metal-enclosed circuit breakers) | Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company |

| Component | Manufacturer |
|---|---|
| Low voltage motor control centers (motor control center assemblies) | Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company |
| UL/NEMA low voltage switchboards | North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer |

## 1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

| Tests | In Accordance With | Conducted By |
|---|---|---|
| | | |

## 1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

| Document Number/Description | Title | Revision |
|---|---|---|
| | | |

# PART 2 – PRODUCTS

## 2.1 MEDIUM VOLTAGE SWITCHGEAR EQUIPMENT

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

### 2.1.1 Switchgear Enclosures

The switchgear shall be furnished with enclosures of the types specified below:

| **Location** | **Description of Enclosure Type** |
|---|---|
| Indoors | Indoor with gasketed doors, ventilated |
| Outdoors | Walk-in protected aisle |

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the instrument panels and the power cable and current transformer compartments.

Each switchgear unit shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other devices. Stops and latches shall be provided for control of each door in the open and closed positions. Each unit of switchgear section shall have a removable rear panel.

#### 2.1.1.1 Outdoor weatherproof

Each unit of switchgear located outdoors shall be furnished with an outdoor weatherproof enclosure furnished with interior hinged front doors as previously specified and an enclosed operating and maintenance aisle. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow the removal of breakers from the front of the units and shall be furnished with a door at each end of the switchgear assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the switchgear shall be coated with a protective sealing compound.

The manufacturer's standard indoor and outdoor lighting (including switching) shall be furnished. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

#### 2.1.1.2 Switchgear space heaters

Each unit of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

Space heater voltage rating shall be approximately twice the applied voltage to increase the operating life.

2.1.1.3 Motor space heaters

When medium voltage motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses throughout the switchgear, and all space heater wiring shall be integral to the switchgear with suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

2.1.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.1.2 Power Circuit Breakers

The switchgear shall be furnished with high voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

### 2.1.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

### 2.1.2.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

### 2.1.2.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

| **Breaker Drawout Position** | **Breaker Operation** | | | |
|---|---|---|---|---|
| | **Remote Control** | | **Local Control Switch** | |
| | **Close** | **Trip** | **Close** | **Trip** |
| Connected | X | X | -- | -- |
| Test | -- | -- | X | X |
| Disconnected | -- | -- | -- | -- |

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

### 2.1.3 Power and Control Conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

#### 2.1.3.1 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

The ungrounded busbars shall be insulated with epoxy, applied using a fluidized bed system or shall be insulated in a manner approved by the Purchaser. Details of the insulation system shall be supplied with the technical data.

All power current carrying connections shall be bolted together. All joints shall have silver-to-silver contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

When incoming and outgoing cable and bus connections are accessed from the rear of the equipment, removable insulating boots shall be used to insulate the bolted connections. The insulation rating of the boot shall not be less than the voltage rating of the equipment.

#### 2.1.3.2 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground conductors directly to the ground bus. The compartment ground buses shall also be furnished with clamp type connectors for attachment of the power circuit ground cables.

2.1.4 External Connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.1.4.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.1.4.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long-barrel, 2 hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.1.4.3 Stress cones

Where power conductors entering a switchgear unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable. Hot or cold shrink type termination kits shall be utilized.

2.1.4.4 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.1.4.5 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the switchgear ground bus and/or bonding the bus duct enclosure to the ground system.

2.1.5 Control Power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets included at the end of this section. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a capacitive charged tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after medium voltage power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

### 2.1.6 Instrument Transformers, Instruments, and Associated Devices.

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

#### 2.1.6.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

Window type current transformers shall have a 5.25 inch (133 mm) diameter circular window or the oval equivalent. Window current transformers shall be mechanically braced to withstand the same momentary current as the circuit breakers with which they are used. Where a window current transformer braced for the same momentary current as the circuit breaker is unavailable with the ratio specified, the Supplier shall furnish a combination of a window current transformer braced for the momentary current of the circuit breaker and an associated auxiliary current transformer. The product of the ratios of the window current transformer and the auxiliary current transformer shall be equal to the ratio specified.

#### 2.1.6.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second; shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design; and shall be compatible with the Purchaser's equipment.

Each transformer shall be provided with current limiting primary fuses and secondary fuses, and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

#### 2.1.6.3 Protective relays

Each breaker unit shall be provided with at least one solid-state or microprocessor type protective relay and, as a minimum, shall have the following protective functions:

| | **ANSI C37 Device Function Number** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **25** | **27** | **46** | **49** | **50** | **50G** | **51** | **51N/G** |
| Incoming main breaker | X | | | | | X | X | |
| Tie breaker | X | | | | | | X | X |
| Bus feeder breaker | | | | | | | X | X |
| Motor feeder breaker | | X | X | X | X | X | | |
| SUS transformer feeder | | | | X | X | X | | |

Relay types to be proposed shall be submitted with the bid documents and shall be subject to approval by the Purchaser.

Auxiliary relays mounted internally shall be surface mounted and front connected.

### 2.1.7 Wiring and Wiring Diagrams

The Supplier shall furnish internal switchgear wiring, connections, and diagrams in accordance with the requirements of the following articles.

#### 2.1.7.1 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

The minimum sizes of wire used in the switchgear for control and instrumentation shall be in accordance with the following table:

| **Minimum Wire Service** | **Size, AWG ($mm^2$)** |
|---|---|
| Power supplies | 12 (4) |
| Current transformer circuits | 12 (4) |
| Indicating lights and annunciator circuits | 16 (1.5) |
| All other wiring | 14 (2.5) |

#### 2.1.7.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

The complete connection diagram of each switchgear unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item of switchgear mounted equipment indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

## 2.2 Medium Voltage Controller Equipment Specification

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

Design and construction of medium voltage controllers shall be in accordance with the requirements of the articles which follow.

### 2.2.1 Enclosures

Each assembly shall be furnished with enclosures of the types specified below:

| **Location** | **Description of Enclosure Type** |
|---|---|
| Indoors | Indoor with gasketed doors, ventilated |
| Outdoors | Weatherproof, walk-in protected aisle |
| Outdoors | Weatherproof, without enclosed operating and maintenance aisle |

Each controller assembly shall consist of a lineup of free-standing metal-enclosed vertical sections interconnected into an integrally built group.

Main contactors and, when required, main incoming circuit breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the medium voltage and low voltage compartments.

2.2.1.1 Front doors

Each controller unit shall include a hinged front door for the medium voltage compartment and a separate hinged front door for the low voltage compartment.

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other specified devices. Doors shall be hinged and shall have turned-back edges and additional bracing where required to ensure rigidity.

2.2.1.2 Indoor general purpose enclosures

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an indoor general purpose enclosure shall be furnished with a hinged front door, as previously specified, and a removable rear panel.

2.2.1.3 Outdoor weatherproof enclosures without an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure without an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an exterior hinged and gasketed front door. The rear of each such unit shall be furnished with a removable gasketed panel or hinged and gasketed door.

Exterior doors shall have concealed hinge construction and three-point single handle operated latches. Exterior door handles shall be locking type; the switchgear enclosures shall be tamper resistant.

Ventilation openings shall be furnished with filters.

One convenience outlet shall be furnished in each switchgear unit. The Supplier shall furnish all convenience outlet wiring integral to the switchgear and suitable branch circuit protection.

The underside of the switchgear shall be coated with protective sealing compound.

2.2.1.4 Outdoor weatherproof enclosures with an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure with an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an enclosed operating and maintenance aisle along the front of the controller assembly. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow removal of breakers from the front of the units and shall be furnished with a door at each end of the controller assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the controller assembly shall be coated with a protective sealing compound.

One 100 watt incandescent lighting fixture shall be furnished in the operating and maintenance aisle for each two controller units, and one 150 watt outdoor incandescent lighting fixture shall be furnished over each exterior aisle door. A weatherproof light switch shall be mounted on the exterior of the controller enclosure adjacent to each exterior aisle door for control of all lights. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

#### 2.2.1.5 Controller space heaters

Where space heaters are specified, all units and the individual compartments of divided units shall be provided with space heaters to prevent condensation of moisture within the enclosures. The heaters shall be spaced away and thermally insulated from any painted surfaces. Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage stated on the Electrical Design and Equipment Data Sheets.

Unless specified otherwise, the Purchaser will provide a single space heater supply feeder to each continuous assembly having a common bus. The Supplier shall furnish contactors, all required internal wiring, suitable branch circuit protection for each space heater circuit, and space heater power buses throughout the controller assembly.

Controller and auxiliary equipment units shall have space heaters controlled by an adjustable thermostat, factory set to close at 85° F (30° C) and to open at 95° F (35° C).

Where a common enclosure and motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall make connections to the space heater bus for the purpose of providing motor space heater power.

#### 2.2.1.6 Motor space heaters

Where a separate motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall furnish wiring through the length of the controller assembly. The Supplier shall make a connection to a terminal block for external connection to each motor space heater from the motor space heater bus or the controller assembly space heater bus, as applicable. Each motor space heater circuit shall be routed through a normally closed auxiliary switch contact or auxiliary contact and shall include suitable branch circuit protection.

#### 2.2.1.7 Nameplates

Engraved nameplates shall be furnished for the front of each unit. Equipment and devices within each unit shall be identified with permanently printed tags or engraved nameplates. Nameplate inscriptions will be provided by the Purchaser at a later date.

### 2.2.2 Incoming Power Circuit Breakers

When required on the Electrical Design and Equipment Data Sheets, the controller assembly shall be furnished with high voltage power circuit breakers of standard drawout design.

The breakers shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Terminal designations shall be as indicated on the typical schematic diagrams furnished by the Supplier.

#### 2.2.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

#### 2.2.2.2 Low current switching capability

In addition to conforming with load current switching capability requirements of the applicable standard, breakers shall be capable of interrupting low current loads and faults as specified herein. Breakers shall be capable of interrupting inductive loads having power factors in the range of 20 percent lagging to 80 percent lagging, with current values in the range of 2 percent to 100 percent of the breaker continuous current rating. These loads shall be interrupted without exceeding the rated interrupting time by more than 2.5 cycles for opening operations and 3.5 cycles for close-open operations.

#### 2.2.2.3 Operating mechanism

Each power circuit breaker shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage.

The operating mechanism shall be of the stored energy type with a closing coil and single or dual shunt trip coils as specified on the Electrical Design and Equipment Data Sheets. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

The operating mechanism shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.2.2.4 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

All spare auxiliary contacts shall be wired to terminal blocks for external connection.

2.2.2.5 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

| **Breaker Drawout Position** | **Breaker Operation** | | | |
|---|---|---|---|---|
| | **Remote Control** | | **Local Control Switch** | |
| | **Close** | **Trip** | **Close** | **Trip** |
| Connected | X | X | -- | -- |
| Test | -- | -- | X | X |
| Disconnected | -- | -- | -- | -- |

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

### 2.2.3 Controllers

Controllers shall consist of an assembly of contactors, primary disconnects, current limiting fuses, transformers, and control and instrument equipment as specified in the articles which follow.

The Supplier shall be responsible for the coordination of the contactors, current transformers, protective relays, and current limiting fuses. In selecting suitable components, the following points must be considered:

1. Protection of the load against sustained overloads and locked-rotor conditions, for motor loads, by opening of the circuit with the contactor by means of the protective relay.

2. Protection of the fuses against sustained currents above their continuous ampere rating but below their melting value by opening of the circuit with the contactor by means of the protective relay.

3. Protection of the feeder circuit within the interrupting limits of the contactor by opening the circuit with the contactor by means of the protective relay and not opening the circuit with the fuses.

4. Protection of the feeder circuit, contactor, current transformers, and protective relay from the damaging effects of maximum fault currents by opening the circuit with properly sized current limiting fuses.

#### 2.2.3.1 Main contactors

Contactors shall be 3-pole, single-throw, vacuum break units furnished electrically and mechanically complete. Contactors shall be capable of carrying the ampere rating as required by the Supplier's design continuously when mounted in a ventilated indoor enclosure in a 104° F (40° C) ambient. Contactors shall be of the magnetically held-in type. When the coil circuit is interrupted, the contactor shall open the feeder circuit. Controller control voltage shall be as specified on the Electrical Design and Equipment Data Sheets. Where an ac control voltage is specified, the contactor coils shall be ac rated or shall be dc rated and shall be supplied from a silicon full wave bridge rectifier furnished on the controller.

Each contactor shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for proper operation of the equipment. Not less than three spare "a" and three spare "b" auxiliary contacts shall be furnished on each contactor. In addition, mechanically operated auxiliary switches shall provide not less than four spare "a" and four spare "b" contacts. The auxiliary switches shall be stationary and shall be mounted in the controller enclosure. All auxiliary switch contacts shall be wired to terminal blocks for use with control circuits where needed.

The contactors shall be capable of carrying their rated full load current continuously without exceeding the temperature rise as specified in the latest applicable standards. The contactors shall be cooled by natural conduction, convection, and radiation. Contactor insulation shall be coordinated with that of the controller assembly structure.

All contactors of the same unit type shall be wired alike and shall be mechanically and electrically interchangeable.

Where drawout contactors are specified, the contactor drawout assembly shall be furnished complete with wheels to provide easy removal from the enclosure.

#### 2.2.3.2 Disconnecting mechanism

A 3-pole externally operated disconnecting mechanism shall be furnished for disconnecting each controller from the bus. For drawout type contactors, operating the mechanism shall disconnect the contactor from the bus and shall operate an automatic insulated shutter to close the openings to the bus. For fixed mounted contactors, operating the mechanism shall open a disconnect switch which will disconnect power to the contactor, power fuses, and control power transformer (if applicable) from the bus. The medium voltage bus shall be isolated from the rest of the medium voltage compartment by insulated barriers or shutters when the disconnect switch is open. The disconnect switch shall have a continuous current rating not less than that of the contactor.

Mechanical interlocking means shall be provided to prevent operating the mechanism with the contactor closed. An electrical interlock shall be provided to trip the contactor before enabling operation of the mechanism. Provisions shall be made to allow padlocking of the disconnecting mechanism handle in both the ON and the OFF positions.

#### 2.2.3.3 Fuses

Current limiting fuses shall be furnished to ensure positive interruption of faults to limit the magnitude of short-circuit current and electromechanical stresses to values within the design limits of the controller assembly components.

In addition, the fuses shall limit the surge voltage produced by short-circuit currents to within allowable limits of the applicable standard.

Power fuses shall be supplied by the Supplier. Easy identification of blown fuses shall be provided by positive action indicators.

Fuses shall be furnished for protection of control power transformers and potential transformers. Control power transformer fuses shall be Buss JCW or equal and shall be E rated.

Fuses shall be designed to prevent discharge of flame or gas when operated and shall not require discharge filters, fire boxes, special vents, or reinforcing.

For drawout design, power fuses shall be mounted on the contactor drawout assembly. Where specified, the power fuses shall be equipped with antisingle-phasing devices to open the contactor on a blown fuse and prevent single-phasing of the load.

### 2.2.4.1 Main bus

Each controller assembly main bus shall be made of the material specified on the Electrical Design and Equipment Data Sheets and shall be capable of carrying rated current continuously without exceeding temperature rise requirements specified in the latest applicable standards.

The bus shall be installed with rigid, nontracking, nonflammable, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the short-time current rating of the largest contactor.

When busbar insulation is specified on the Electrical Design and Equipment Data Sheets, all buses which are to be insulated shall be furnished with an insulating sleeve, coated with epoxy type insulating material or acceptable equal molded around and bonded to the bus, or shall be taped, except at bolted terminations and connection points. All bolted joints; expansion joints; and all bus connections, factory or field, shall be insulated with removable boots. Removable boots shall be designed to overlap bus insulation a minimum of 1 inch (25 mm). Insulation rating of bus, joint, connection, and terminal insulation shall be at least equal to the voltage rating of the equipment.

All joints shall have minimum contact resistance and, when specified, shall have tinned or silver contact surfaces.

The main bus shall be arranged Phase A (1), Phase B (2), and Phase C (3), from left to right, from front to back, and from top to bottom when facing the front (operating side) of the controller assembly.

### 2.2.4.2 Ground (earthing) bus

An uninsulated copper ground (earthing) bus, with a momentary short-time rating at least equal to the momentary and short-time rating of the largest contactor, shall be furnished through the entire length of each controller assembly. All of the assembly equipment requiring grounding (earthing) shall be connected to this ground (earthing) bus. Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground (earthing) conductors directly to the ground (earthing) bus. Where specified on the Electrical Design and Equipment Data Sheets, the compartment ground (earthing) bus shall also be furnished with a clamp type connector for attachment of the power circuit ground (earthing) cable. Provisions shall be made for the attachment of 2/0 AWG (70 mm$^2$) to 4/0 AWG (120 mm$^2$) stranded copper cable to each end of the ground (earthing) bus in each end section of the assembly for external connection to the station ground (earthing) grid.

#### 2.2.4.3 Bus connections

Connections between the main buses and disconnecting devices, instrument transformers, and contactors shall be furnished and installed with an insulating cover equal to the insulation of the main bus (if so insulated). All main current carrying connections shall be made by bolting together flat bar. Insulated cable connections shall be furnished for the control power transformers (if applicable).

Current transformer primary connections shall be designed to allow easy removal and replacement of the transformers without damage to the connections.

All material required for field connection and insulation of bus and terminals shall be provided if an insulated bus system is furnished.

### 2.2.5 External Connections

Facilities for the entrance, support, termination, and connection of power supply and feeder conductors shall be provided in accordance with the requirements of the articles which follow.

#### 2.2.5.1 Entrance

Adequate openings shall be furnished for all conductors entering each controller assembly. Cable entrance will be from above or below as indicated on the Electrical Design and Equipment Data Sheets.

#### 2.2.5.2 Terminal connectors

Terminal connectors for all power cable and external ground (earthing) conductors entering each controller assembly shall be provided and shall be the same as, or an acceptable equal to, the following terminals. Solder type terminals are not acceptable:

| **Copper Conductor Cable Size, AWG (mm$^2$)** | **Burndy Terminal Connectors Compression Type** |
|---|---|
| 8 (10) and smaller | YAV |
| 6 (16) and larger | YA-2N (long barrel) |

#### 2.2.5.3 Stress cones

Where the power conductors entering a controller unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable.

Cable termination points and current transformers shall be arranged for convenient routing of the power conductors (from the direction specified) to the terminal point. Proper clearances and bending space shall be provided.

2.2.5.4 Bus duct

Where bus duct is utilized for power conductors, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.2.5.5 Ground bus

Ground cable connectors shall be furnished for the attachment of stranded copper cable to the ground (earthing) bus for external connection to the station grounding (earthing) system. Connectors shall be furnished at each end of the controller assembly ground (earthing) bus. Each controller unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each controller unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing) bus to the switchgear ground (earthing) bus.

2.2.6 Control Power

Electrical power for control and instrumentation shall be as required by Supplier's design.

Where dc control power is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall provide a common bus throughout the controller assembly requiring a single connection of dc control power from the Purchaser. Suitable branch circuit protection and control power disconnecting means shall be provided for each controller unit.

The paragraphs which follow apply only to ac control power.

Where ac control power is specified on the Electrical Design and Equipment Data Sheets, all control power requirements necessary to operate each controller shall be provided by means of individual control power transformers. Each controller unit shall be provided with an individual transformer for control and instrumentation associated with that controller only.

Control power transformers shall be rated not less than 1 kVA. Each control power transformer shall be provided with primary and secondary fuses. The size of each control power transformer shall be clearly indicated on each section schematic and wiring diagram submitted for review.

Control power interlocking provisions shall be provided to allow testing of the control operation of each controller from an external source of control power with the contactor disconnected and isolated from the main bus.

Control power interlocking provisions shall not allow the control power transformer of the controller to be energized during testing as described above.

The Supplier shall furnish a manually operated switch to transfer the control power from the normal source to the external test circuit source.

### 2.2.7 Instrument Transformers, Instruments, and Associated Devices

Instrument transformers shall be designed for use with meters, relays, and instruments, in accordance with the latest applicable standards. Instrument transformer secondary leads shall be brought out to terminal blocks grouped for the connection of external circuits.

#### 2.2.7.1 Current transformers

Current transformer thermal and mechanical limits shall be coordinated with the short-time rating of the controller with which they shall be used. All current transformers shall be single ratio unless otherwise specified. All current transformer leads shall be brought out to shorting type terminal blocks arranged to provide any combination of connections or polarity.

Window type current transformers for zero sequence fault current sensing shall be provided for each controller when ground (earth) fault protection is specified. The transformers shall be installed in accordance with the recommendations of the relay manufacturer. Where bottom entry is specified, the transformers shall be spaced above the enclosure bottom to allow the cable shield ground (earthing) conductor to be brought through and connected to the ground (earthing) bus.

#### 2.2.7.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses. When voltage transformers are supplied in a drawout assembly, the drawout unit shall have the primary fuses mounted on it and shall be designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

#### 2.2.7.3 Protective relays

Protective relays shall be as required by the Supplier's design. In addition, specific relay types and/or functions, if required by the Purchaser, are indicated on the Electrical Design and Equipment Data Sheets. Protective relays shall be flush mounted, induction or static drawout type, or microprocessor type, equipped with built-in test switches and operation counters.

Auxiliary relays mounted internally shall be surface mounted, front connected.

Field application relays and controls shall be provided for all synchronous motors.

### 2.2.7.4 Control and instrument switches

All controllers shall have, mounted on the front instrument panel, red and green indicating lights and either START and STOP push buttons or a multistage control switch equipped with modern pistol grip handle.

Unless specified otherwise on the Electrical Design and Equipment Data Sheets, each local control switch shall be wired to close its contactor only when the contactor is in the TEST position. When in the OPERATE position, the contactor may be tripped with either the local emergency stop push button, protective relay trip, or the remote input.

### 2.2.8 Wiring and Wiring Diagrams

The Supplier shall provide internal wiring, connections, and diagrams in accordance with the requirements of the articles which follow.

### 2.2.8.1 Control and instrument wiring

All low voltage control and instrument wiring used within the controller assemblies.

All internal wiring shall be neatly and carefully installed and shall be terminated on terminal blocks or devices. Conductors and terminals shall be plainly lettered or marked in accordance with the manufacturer's connection diagrams. Any controller assembly that is split for shipment shall have terminal blocks adjacent to the split and shall be provided with wiring required to interconnect the shipping sections.

All leads for external circuit wiring shall be connected to terminal blocks located for convenient connection of external circuits. Splices will not be permitted in control wiring or instrument leads.

The minimum sizes of wire used in the controller assembly for control and instrumentation shall be in accordance with the following table:

| **Minimum Wire Service** | **Size, AWG ($mm^2$)** |
|---|---|
| Power supplies | 12 (4) |
| Current transformer circuits | 12 (4) |
| Indicating lights and annunciator circuits | 16 (1.5) |
| All other wiring | 14 (2.5) |

All spare contacts on relays, control switches, limit switches, or similar devices shall be wired to accessible terminal blocks for the Purchaser's future connections. All wiring leaving an enclosure shall leave from terminal blocks and not from other devices within the enclosure.

Terminal blocks shall not be mounted in compartments containing cable or bus operating at voltages above 600 volts.

Control and potential buses, as required, shall be switchboard wire installed at the rear of the instrument and control compartment.

Each terminal block, conductor, relay, circuit breaker, fuse block, and other auxiliary devices and terminals shall be permanently labeled to coincide with the identification indicated on the drawings. All wiring terminations shall be identified by legible markings on the device terminals.

#### 2.2.8.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein. Controller schematic, connection, and interconnection diagrams furnished by the Supplier shall be based on schematic (elementary) diagrams and connection diagrams furnished by the Purchaser.

The typical schematic diagram of each type of controller specified shall be submitted with the proposal.

The Supplier shall prepare his schematic (elementary), connection, and interconnection diagrams which shall have terminal designations and terminal arrangement acceptable to the Engineer.

The complete connection diagram of each controller unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire controller as it will be physically constructed, including wiring on the contactor itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each section shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Information indicated on the Supplier's drawings shall include wiring of the individual units as they will actually appear in the assembly, contact arrangements of switches, and internal wiring of relays and instruments.

Each item of mounted equipment indicated on the diagrams shall be identified by item number and name.

#### 2.2.8.3 Wiring method

If the wiring method is to be an internal programmable logic controller (PLC) as indicated on the Electrical Design and Equipment Data Sheets, then the Supplier shall furnish a Purchaser-approved PLC in each shipping split of each controller assembly. All control wiring from the device contacts and protective relays to the internal PLC shall be installed by the Supplier as indicated on the typical schematics. The Purchaser will program the PLCs as required.

If a remote PLC is to be used as indicated on the Electrical Design and Equipment Data Sheets, the Supplier has no responsibility to provide or connect device contacts and protective relays to the PLC.

### 2.2.9 Tightening of Connections

The Supplier shall include on his erection and assembly drawings complete information for tightening of all electrical connections secured with bolts or studs. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints, connector attachments, and contact attachments.

## 2.3 Low Voltage Switchgear and Motor Control Equipment

This technical specification is intended for procurement of low voltage metal-clad switchgear and low voltage motor controllers provided as part of a furnish and erect contract. The Supplier shall provide a standard design for items within the scope of this specification, but not covered in detail by these specifications. The standard design shall be in accordance with accepted industry practices and standards for electrical power generation.

### 2.3.1 Low Voltage Switchgear

Low voltage switchgear shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

#### 2.3.1.1 Switchgear enclosures

The switchgear shall be furnished with enclosures of the types specified below:

| **Location** | **Description of Enclosure Type** |
|---|---|
| Indoors | Indoor with gasketed doors, ventilated |
| Outdoors | Walk-in protected aisle |

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front and shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Each unit of switchgear section shall have a removable rear panel.

#### 2.3.1.2 Switchgear space heaters

Each vertical section of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

#### 2.3.1.3 Motor space heaters

When motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses to the required sections. All space heater wiring shall be integral to the switchgear and have suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

#### 2.3.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

#### 2.3.1.5 Power circuit breakers

The switchgear shall be furnished with low voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver- or tin-plated, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Motor-operated breakers shall be provided with means to manually trip the breaker in an emergency.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

##### 2.3.1.5.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.1.5.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

2.3.1.5.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

| **Breaker Drawout Position** | **Breaker Operation** | | | |
|---|---|---|---|---|
| | **Remote Control** | | **Local Control Switch** | |
| | **Close** | **Trip** | **Close** | **Trip** |
| Connected | X | X | -- | -- |
| Test | -- | -- | X | X |
| Disconnected | -- | -- | -- | -- |

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

2.3.1.6 Power and control conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to 104° F (+40° C). Expansion joints shall be furnished where required.

2.3.1.7 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

All power current carrying connections shall be bolted together. All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

2.3.1.8 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.1.9 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.1.9.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.3.1.9.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.1.9.3 Bus Duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.1.9.4 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground (earthing) bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing) bus to the switchgear ground (earthing) bus and/or bonding the bus duct enclosure to the ground system.

2.3.1.10 Control power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

2.3.1.11 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.1.11.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.1.11.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.3.1.12 Protective relaying devices

Each breaker unit shall be provided with a solid-state protective device and, as a minimum, shall have the following protective functions. Long-time and short-time functions shall have field adjustable current and time-delay settings. The current setting for instantaneous phase trip shall have a field adjustable current setting:

| | **Long-Time Phase Trip** | **Short-Time Phase Trip** | **Instantaneous Phase Trip** |
|---|---|---|---|
| Incoming main breaker | X | X | |
| Tie breaker | X | X | |
| Feeder breaker | X | X | X |
| Motor controller | X | X | X |

Ground fault protection shall also be provided for all breakers for solidly grounded systems and shall be coordinated upstream and downstream as appropriate.

Auxiliary relays mounted internally shall be surface mounted and front connected.

### 2.3.2 Low Voltage Motor Control Assemblies

Low voltage control assemblies shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

#### 2.3.2.1 Enclosures

The motor control assemblies shall be furnished with enclosures of the types specified below:

| **Location** | **Description of Enclosure Type** |
|---|---|
| Indoors - clean | Indoor gasketed |
| Indoors - dusty areas | Indoor dustproof |
| Outdoors | Nonwalk-in weatherproof with filters |

Each assembly shall consist of motor controllers, main and tie breakers (as required), and feeder breakers mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures. Controllers and feeder breakers shall be mounted as individual units separated by grounded steel barriers for other units and, where possible, shall be withdrawable from the front. Each controller or breaker unit shall be furnished with hinged front door(s). Each vertical section shall have a removable rear panel (except in the case of back-to-back construction).

##### 2.3.2.1.1 Space heaters

When located outdoors, each vertical section shall be furnished with space heaters to prevent condensation of moisture within the section. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified.

Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

2.3.2.1.2 Motor space heaters

When motors controlled by the lineup have space heaters, the Supplier shall furnish space heater power buses throughout the motor control lineup. All space heater wiring shall be integral to the lineup and have suitable branch circuit protection. Motor space heater circuits shall also include connections to controller auxiliary contacts and connections to terminal blocks for external connections.

2.3.2.1.3 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.3.2.2 Motor controllers

Combination motor controllers shall be of standard drawout design (when possible) with the following features. Except where required by the Supplier's design, single-speed, full voltage, nonreversing starters shall be used:

Molded case circuit protectors (MCCP) for disconnecting power and magnetic-only short-circuit protection for high magnitude faults. The drawout function shall be disabled when the MCCP is closed.

When the manufacturer's design does not permit the starter unit to be drawout type because of size limitations, a fused, load-break, disconnect device shall be provided in lieu of an MCCP. The fuses shall be disconnected from the power source when the switch is open. Single phasing protection shall be provided.

Bimetallic or solid-state, 3-phase, ambient compensated, overload devices provide suitable overload protection for the motors.

Auxiliary relays as required for the Supplier's design.

Interposing relays as required by the Supplier's process controller.

Control power transformers (with primary and secondary fuses, 100 VA minimum).

2.3.2.3 Main and tie breakers

Main and tie circuit breakers, when furnished in motor control centers, shall be fixed mounted, molded case design. Means to coordinate instantaneous (and ground fault for solidly grounded systems) tripping functions of feeder breakers and MCCPs with main and tie breakers shall be provided. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with th e indicated industry standards for the nominal system voltage utilized.

2.3.2.4 Feeder breakers

Feeder circuit breakers, when furnished in motor control centers, shall be molded case design and shall be withdrawable when available. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.2.5 Power and control conductors

MCC power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

2.3.2.6 Main bus

The MCC main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings as specified.

All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

2.3.2.7 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.2.8 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.2.8.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the equipment.

2.3.2.8.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.2.8.3 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.2.8.4 Ground (earthing)

Connectors shall be furnished at each end of the assembly ground bus for connection of cables from the station ground grid.

Each unit designed for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the assembly ground bus and/or bonding the bus duct enclosure to the ground system.

2.3.2.9 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.2.9.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.2.9.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.3.2.10 Wiring and wiring diagrams

The Supplier shall furnish internal switchgear and motor control assembly wiring, connections, and diagrams in accordance with the requirements of the following articles.

### 2.3.2.11 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

### 2.3.2.12 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

#### 2.3.2.12.1 Diagrams for equipment within the supplier’s scope of supply

The complete connection diagram of each unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

#### 2.3.2.12.2 Diagrams interconnection of purchaser’s system

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

## 2.4 Low Voltage Power Distribution Equipment

## ELECTRICAL DESIGN AND EQUIPMENT

When specified to be in the Supplier's scope of supply, the Supplier shall supply low voltage power distribution equipment in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

### 2.4.1 Low Voltage Panelboards and Switchboards

Low voltage power panelboards and switchboards shall be furnished in accordance with the following articles.

#### 2.4.1.1 Enclosures

Panelboards and switchboards shall be furnished with enclosures of the types as follows:

| **Location** | **Description of Enclosure Type** |
|---|---|
| Indoors - clean area | Indoor with gasketed cover, ventilated |
| Indoors - dusty area | Indoor dustproof enclosure, unventilated |
| Outdoors - protected | Combination outdoor/dustproof, unventilated |
| Outdoors - unprotected | Washdown/dustproof, unventilated |
| Hazardous | Listed for conditions present |

#### 2.4.1.2 Busing

Main, neutral, and ground busing shall be copper. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design.

#### 2.4.1.3 Circuit breakers

Main breakers shall be provided in all panelboards and switchboards. Main and feeder breakers shall be molded case, bolt-in type. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design. Breakers and busing shall be individually rated and labeled for the required short-circuit amperes available. Tandem or miniature circuit breakers shall not be used.

#### 2.4.1.4 Spares

Total expected load on each panelboard or switchboard shall not exceed 80 percent of its continuous current rating. At least one spare feeder breaker of each size and number of poles used for loads shall be provided in each panelboard and switchboard. At least six poles of spare space shall be provided in each panelboard and switchboard.

### 2.4.2 Dry Type Distribution Transformers

Dry type distribution transformers shall be used indoors in dry areas only and shall meet the following requirements:

Shall have copper windings rated for 302° F (150° C) temperature (by resistance) rise above 104° F (40° C) ambient.

Shall be sized to approximately match the nominal ampacity of the panelboard or switchboard which is connected to its secondary terminals.

Sound level shall not exceed 45 dBA when measured in accordance with NEMA standards.

When installed in areas where dirt and dust are present, shall have filters installed on vent openings or shall be nonventilated.

Shall be appropriately derated when the ambient temperature exceeds 104° F (40° C).

### 2.4.3 Nameplates

Engraved nameplates shall be furnished for the front of each item of equipment.

## PART 3 – EXECUTION

Not Applicable.

| | |
|---|---|
| **Medium Voltage Switchgear** | |
| Medium voltage switchgear enclosure type | Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** As required by Supplier's design |
| Power supply to medium voltage switchgear assemblies provided by Purchaser | 120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC |
| Separate control power supply to medium voltage switchgear assemblies provided by Purchaser | 120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC |
| Separate space heater power supply to medium voltage switchgear assemblies provided by Purchaser (single supply) | 120 VAC **or** 230 VAC |
| **Medium Voltage Controller** | |
| Medium voltage controller enclosure type | Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** Outdoor without enclosed operating and maintenance aisle **or** As required by Supplier's design |
| Power supply to medium voltage controller assemblies provided by Purchaser | 120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC |
| Separate control power supply to medium voltage controller assemblies provided by Purchaser | 120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC |
| Separate space heater power supply to medium voltage controller assemblies provided by Purchaser (single supply) | 120 VAC **or** 230 VAC |
| Medium voltage controller main incoming power circuit breaker required | Yes **or** No |
| Single or dual shunt trip coils | Single |
| Controller construction | Maximum two-high stacking **or** Maximum one-high stacking **or** Maximum three-high stacking **or** Manufacturer's standard |
| Drawout contractors required | Yes **or** No |
| Busbar insulation required | Yes **or** No |
| Controller cable entrance | Above **or** Below **or** As required by Supplier's design |
| Clamp type connectors required on compartment ground (earthing) bus for attachment of power circuit ground cable | Yes **or** No |
| Control voltage | 120 VAC **or** 230 VAC **or** 125 VDC **or** 250 VDC |

| **Low Voltage Switchgear and Motor Control Centers** |  |
|---|---|
| Single power supply to assembly provided by Purchaser | 120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC |
| Low voltage switchgear enclosure type | Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** As required by Supplier's design |
| Motor control center enclosure type | Indoor, gasketed **or** Indoor, dustproof **or** Outdoor, nonwalk-in weatherproof with filters **or** As required by Supplier's design |
| **Low Voltage Panelboards and Switchboards** |  |
| Enclosure type | Indoors with gasketed cover, ventilated **or** Indoor, dustproof enclosure, unventilated **or** Outdoor, combination outdoor/dustproof, unventilated **or** Outdoor, washdown/dustproof, unventilated **or** Hazardous, listed for conditions present **or** As required by Supplier's design |

END OF SECTION 260510

# SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

### 1.3 DEFINITIONS

A. VFC: Variable frequency controller.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

### 1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS AND CABLES

A. See WSU design standards.

B. **Aluminum and Copper** Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for **Type THHN/THWN-2**.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for **nonmetallic-sheathed cable, Type NM** with ground wire.

### 2.2 CONNECTORS AND SPLICES

A. See WSU design standards.

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

### 2.3 SYSTEM DESCRIPTION

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

B. Comply with NFPA 70.

## PART 3 - EXECUTION

### 3.1 CONDUCTOR MATERIAL APPLICATIONS

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

B. Branch Circuits: Copper. Solid for **No. 10** AWG and smaller; stranded for **No. 8** AWG and larger, except VFC cable, which shall be extra flexible stranded.

### 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: **Type THHN/THWN-2, single conductors in raceway.**

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: **Type THHN/THWN-2, single conductors in raceway**.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: **Type THHN/THWN-2, single conductors in raceway**.

D. Feeders Installed below Raised Flooring: **Type THHN/THWN-2, single conductors in raceway**.

E. Feeders in Cable Tray: **Type THHN/THWN-2, single conductors in raceway**.

F. Exposed Branch Circuits, Including in Crawlspaces: [**Type THHN/THWN-2, single conductors in raceway**] [**Armored cable, Type AC**] [**Metal-clad cable, Type MC**] [**Mineral-insulated, metal-sheathed cable, Type MI**] [**Nonmetallic-sheathed cable, Type NM**].

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: **Type THHN/THWN-2, single conductors in raceway**.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: **Type THHN/THWN-2, single conductors in raceway**.

I. Branch Circuits Installed below Raised Flooring: **Type THHN/THWN-2, single conductors in raceway**.

J. Branch Circuits in Cable Tray: **Type THHN/THWN-2, single conductors in raceway**.

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

## 3.3 INSTALLATION OF CONDUCTORS AND CABLES

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

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

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

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

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

## 3.4 CONNECTIONS

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

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

   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least [**6 inches (150 mm)**] [**12 inches (300 mm)**] of slack.

## 3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

## 3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

## 3.8 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections:

   1. After installing conductors and cables and before electrical circuitry has been energized, test **conductors feeding the following critical equipment and services** for compliance with requirements.

    a. Back-up generators, Panelboards, automatic transfer switches, uninterruptable power sources, transformers, and associated switches.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

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

D. Test and Inspection Reports: Prepare a written report to record the following:

    1. Procedures used.
    2. Results that comply with requirements.
    3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

# SECTION 260526 – DIESEL GENERATOR SET NEUTRAL GROUNDING (EARTHING) EQUIPMENT

## PART 1 - GENERAL

### 1.1 SCOPE OF SUPPLY

Scope of supply shall include furnishing the generator neutral grounding (earthing) equipment as defined in these specifications.

### 1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply include the following:

(later)

### 1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the generator neutral grounding (earthing) equipment are indicated on the Generator Neutral Grounding (Earthing) Equipment Specification Sheets included at the end of this section.

### 1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

| **Work** | **In Accordance With** |
|---|---|
| Generator neutral grounding (earthing) equipment | ANSI/NEMA |

### 1.5 MATERIALS

The following materials shall be used:

| **Component** | **Material** |
|---|---|
| Generator neutral grounding (earthing) equipment | Refer to Article 16142.2.2, Equipment Requirements |

## 1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

| Component | Manufacturer |
|---|---|
| Generator neutral grounding (earthing) equipment | (Later) |

## 1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

| Tests | In Accordance With | Conducted By |
|---|---|---|
| Routine shop tests | ANSI/NEMA | Manufacturer |

## 1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

| Document Number/Description | Title | Revision |
|---|---|---|
| Engineering Building CAI 32004-S-1 | 2000 KW Diesel Generator 480V 3Ø 60Hz | |
| Physics Building CAI 320003-S-1 | 1000 KW Diesel Generator 480V 3Ø 60Hz | |

# DIESEL GENERATOR SET NEUTRAL GROUNDING (EARTHING) EQUIPMENT

## PART 2 - PRODUCTS

### 2.1 GENERAL

This article covers the furnishing of neutral grounding (earthing) equipment, materials, and accessories that shall be designed for use with the generator.

### 2.2 EQUIPMENT REQUIREMENTS

Neutral grounding (earthing) equipment designed for use with the generator shall be furnished.

The equipment shall include one indoor generator neutral grounding (earthing) equipment enclosure with the following items furnished, mounted, and connected within the enclosure. Transformer and resistor ratings indicated on the Generator Neutral Grounding (Earthing) Equipment Specification Sheets are for bid purposes only. The required ratings will be specified later:

Grounding (Earthing) Transformer. Provide one grounding (earthing) transformer, distribution type, single-phase. High voltage terminals are to have connectors for cable as large as 250 mcm (150 mm$^2$).

Resistor. Provide one resistor, cast grid type, connected to shunt the secondary winding of the transformer. Connections shall be provided from the resistor to an easily accessible terminal block for remote relaying.

Disconnect Switch. Provide one no-load disconnect switch, single-pole, single-throw, hook operated type for disconnecting neutral grounding (earthing) equipment from the generator neutral. A hook stick complete with handle shall be provided with the switch.

Ground Bus. Provide one ground bus with provisions for attachment of a 1/0 AWG (50 mm$^2$) to 300 mcm (185 mm$^2$) stranded copper cable. All equipment requiring grounding (earthing) shall be connected to this bus.

Terminal Block. Provide one terminal block, connected to the grounding (earthing) transformer secondary for extension to remote protective relays furnished under separate specifications.

The enclosure shall be fabricated from leveled steel sheets not less than 11 USS gauge (minimum 3 mm), reinforced with welded steel or aluminum members to form a rigid free-standing structure. Doors with concealed hinges and three-point latches shall be provided on the front and rear of the enclosure for equipment access. Latch assembly shall include lock type handles. One-quarter inch (6 mm) mesh screened ventilating louvers shall be provided to dissipate heat generated by the enclosed equipment under rated operating conditions. Internal barriers shall be provided to isolate the various items of equipment within the enclosure.

All interconnections between components within the neutral grounding (earthing) equipment enclosure shall be with solid copper bus or with stranded copper cables.

Engraved nameplates shall be furnished for the front and rear of the enclosure. Nameplate inscription will be furnished by the Purchaser at a later date.

If insulated single conductor copper cable is specified on the Generator Neutral Grounding (Earthing) Equipment Specification Sheets for connection from the generator neutral terminal bus to the neutral grounding (earthing) equipment, the cable shall be shipped coiled within the neutral grounding (earthing) equipment enclosure by the Supplier.

## 2.3 TIGHTENING OF CONNECTIONS

The Supplier shall include on his erection and assembly drawings complete information for tightening all electrical connections secured with bolts or studs. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints and connector attachments.

## 2.4 EXECUTION

Not Used.

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DIESEL GENERATOR SET NEUTRAL GROUNDING (EARTHING) EQUIPMENT

| | |
|---|---|
| • **Grounding (Earthing) Transformer** | • |
| • Item | • |
| • Description | • |
| • Transformer type | • Dry type |
| • Capacity, kVA | • 30 |
| • Primary voltage, kV | • Generator LN voltage * 1.2 |
| • Secondary voltage, V | • 240/120 |
| • Basic impulse insulation level, kV | • IEEE 141;  110 kV BIL<br>• 75 kV peak (12 kV-Series I) **or** 95 kV peak (17.5 kV-Series I) **or** 110 kV peak (15 kV-Series II, **or** 125 kV peak (24 kV-Series I) **or** 150 kV peak (25.8 kV, Series II |
| • **Grounding (Earthing) Resistor** | • |
| • Item | • |
| • Description | • |
| • Resistance, ohms/sec **or** ohms/min | Later |
| • Current limit | • |
| • **Disconnect Switch** | • |
| • Item | • |
| • Description | Later |
| • Voltage, V | • |
| • Current, amps | • |
| • **Neutral Grounding (Earthing) Cable** | • |
| • Furnished by | • Purchaser |
| • Size, AWG (mm$^2$ **or** mcm) | Later |
| • Insulation | • |
| • Length, ft (m) | • |
| • **Enclosure Type** | • NEMA 12 |
| • **Additional Requirements** | • |

END OF SECTION 260526

# SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

### 1.3 ACTION SUBMITTALS

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

### 1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Ground rods.
   2. Ground rings.
   3. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

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

1. In addition to Operation and Maintenance Data include the following:

   a. Instructions for periodic testing and inspection of grounding features

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

## 1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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

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

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Comply with WSU Standard requirements.

## 2.2 SYSTEM DESCRIPTION

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

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

## 2.3 CONDUCTORS

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

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, **1/4 by 4 inches (6.3 by 100 mm)** in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

## 2.4 CONNECTORS

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

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

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

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

## 2.5 GROUNDING ELECTRODES

A. Ground Rods: **Copper-clad3/4 inch by 10 feet (19 mm by 3 m)**.

1. Backfill Material: Electrode manufacturer's recommended material.

# PART 3 - EXECUTION

## 3.1 APPLICATIONS

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

B. Underground Grounding Conductors: Install bare copper conductor, **No. 2/0** AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

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

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

1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

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

## 3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

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

## 3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

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

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

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

## 3.4 EQUIPMENT GROUNDING

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

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Receptacle circuits.
3. Single-phase motor and appliance branch circuits.
4. Three-phase motor and appliance branch circuits.
5. Flexible raceway runs.
6. Armored and metal-clad cable runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than **No. 8** AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

## 3.5 INSTALLATION

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

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

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

  1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: **Owner will engage** a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections.

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

D. Tests and Inspections:

  1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal **at individual ground rods**. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

  4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

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

F. Prepare test and inspection reports.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Owner's representative promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

# SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

    a. Hangers.
    b. Steel slotted support systems.
    c. Nonmetallic support systems.
    d. Trapeze hangers.
    e. Clamps.
    f. Turnbuckles.
    g. Sockets.
    h. Eye nuts.
    i. Saddles.
    j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawing: For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Nonmetallic slotted-channel systems.
4. Equipment supports.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

## 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:
   a. Access panels.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

## 2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

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

1. Material: **Galvanized steel**.
2. Channel Width: **1-5/8 inches (41.25 mm)**.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Aluminum Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
   1. Channel Width: **1-5/8 inches (41.25 mm)**.
   2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   4. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
   5. Channel Dimensions: Selected for applicable load criteria.

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

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

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

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

   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   2. Mechanical-Expansion Anchors: Insert-wedge-type, **zinc-coated steel**, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   6. Toggle Bolts: **All-steel** springhead type.
   7. Hanger Rods: Threaded steel.

## 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

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

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

## PART 3 - EXECUTION

### 3.1 APPLICATION

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

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as **scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in** NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

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

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

### 3.2 SUPPORT INSTALLATION

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

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

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

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: **Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts**
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

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

## 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

## 3.4 CONCRETE BASES

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

B. Use **4000psi**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in **Section 033000 "Cast-in-Place Concrete."**

C. Anchor equipment to concrete base as follows:

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

## 3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

# SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

### 1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

D. EMT: Electrical metallic tubing.

### 1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

## 1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

# PART 2 - PRODUCTS

## 2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. ARC: Comply with ANSI C80.5 and UL 6A.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; **zinc-coated steel**.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

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

## 2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ENT: Comply with NEMA TC 13 and UL 1653.

C. RNC: **Type EPC-40-PVC**, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. LFNC: Comply with UL 1660.

E. Rigid HDPE: Comply with UL 651A.

F. Continuous HDPE: Comply with UL 651B.

G. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

H. RTRC: Comply with UL 1684A and NEMA TC 14.

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

J. Fittings for LFNC: Comply with UL 514B.

K. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

L. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

B. Wireway Covers: **Screw-cover type** unless otherwise indicated.

C. Finish: Manufacturer's standard enamel finish.

## 2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

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

E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. **Manufacturer's standard enamel finish in color selected by Owner**

## 2.6 BOXES, ENCLOSURES, AND CABINETS

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

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

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, **ferrous alloy**, Type FD, with gasketed cover.

D. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Cabinets:

1. NEMA 250, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers.

1. Standard: Comply with SCTE 77.
2. Color of Frame and Cover: **Gray**.
3. Configuration: Designed for flush burial unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

## 2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

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

# PART 3 - EXECUTION

## 3.1 RACEWAY APPLICATION

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

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

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

1. Exposed, Not Subject to Physical Damage: **EMT**.
2. Exposed, Not Subject to Severe Physical Damage: **EMT**.
3. Exposed and Subject to Severe Physical Damage: **GRC**. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: **EMT.**
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: **GRC**.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 **stainless steel** in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: **3/4-inch** **(21-mm)** trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

## 3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

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

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

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

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches (300 mm)of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m)intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of **2 inches (50 mm)** of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

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

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

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

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm)radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Mount boxes at heights indicated on Drawings.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

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

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

## 3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

## 3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.5 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

## 3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

# SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

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

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

## PART 2 - PRODUCTS

### 2.1 SLEEVES

A. Wall Sleeves:

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

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

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

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

F. Sleeves for Rectangular Openings:

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

## 2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: **EPDM** rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: **Carbon steel**.
3. Connecting Bolts and Nuts: **Carbon steel, with corrosion-resistant coating,** of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

## 2.4 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

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

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

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

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide **1/4-inch** **(6.4-mm)** annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors **2 inches** **(50 mm)** above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

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

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

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

## 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

## 3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

END OF SECTION 260544

# SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

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

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

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

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

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

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

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

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: **120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces**.

## 2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. **Black letters on an orange field**.
2. Legend: Indicate voltage **and system or service type**.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

## 2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. See WSU design standards.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

1. See WSU design standards.

C. Self-Adhesive Labels:

1. See WSU design standards.
2. **Preprinted**, 3-mil- (0.08-mm-) thick, **vinyl** flexible label with acrylic pressure-sensitive adhesive.

    a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the **raceway** diameter, such that the clear shield overlaps the entire printed legend.

3. **Vinyl**, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

    a. Nominal Size: 3.5-by-5-inch (76-by-127-mm).

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

## 2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

1. See WSU design standards.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

1. See WSU design standards.

## 2.5 TAPES AND STENCILS:

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

1. See WSU design standards.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

1. See WSU design standards.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

   1. See WSU design standards.

D. Underground-Line Warning Tape

   1. See WSU design standards.
   2. Tape:

      a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical **and communications** utility lines.
      b. Printing on tape shall be permanent and shall not be damaged by burial operations.
      c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

   3. Color and Printing:

      a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
      b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
      c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

   4. Tag: **Type I**:

      a. Pigmented polyolefin, bright colored, compounded for direct-burial service.
      b. Width: 3 inches (75 mm).
      c. Thickness: 4 mils (0.1 mm).
      d. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
      e. Tensile according to ASTM D 882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).

E. Stenciled Legend: In nonfading, waterproof, **black** ink or paint. Minimum letter height shall be **1 inch (25 mm)**.

## 2.6 Tags

A. Nonmetallic Preprinted Tags: Polyethylene tags, **0.015 inch (0.38 mm)** thick, color-coded for phase and voltage level, with factory **screened** permanent designations; punched for use with self-locking cable tie fastener.

   1. See WSU design standards.

B. Write-On Tags:

   1. See WSU design standards.

2. Polyester Tags: **0.010 inch (0.25 mm)** thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

## 2.7 Signs

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:
    a. For signs up to 20 sq. inches (129 sq. cm), minimum 1/16-inch- (1.6-mm-).
    b. For signs larger than 20 sq. inches (129 sq. cm), 1/8 inch (3.2 mm) thick.
    c. Engraved legend with **black letters on white face**.
    d. **Punched or drilled for mechanical fasteners**.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. See WSU design standards.

## 2.8 CABLE TIES

A. See WSU design standards.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

## 2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

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

# PART 3 - EXECUTION

## 3.1 PREPARATION

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

## 3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

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

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

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

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

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

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

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

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

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

## 3.3 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply stripes to the following finished surfaces:

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

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: **Self-adhesive vinyl** labels. Install labels at **30-foot (10-m)** maximum intervals.

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

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

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

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

  1. Color-Coding for Phase-**and Voltage-Level** Identification, 600 V or Less: Use colors listed below for ungrounded **feeder and branch-circuit** conductors.

    a. Color shall be factory applied **or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit**.
    b. Colors for 208/120-V Circuits:

      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.

    c. Colors for 480/277-V Circuits:

      1) Phase A: Brown.
      2) Phase B: Orange.
      3) Phase C: Yellow.

    d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation**.

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

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use **self-adhesive vinyl labels** with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide **self-adhesive vinyl labels** with the conductor designation.

J. Conductors To Be Extended in the Future: Attach **marker tape** to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

  1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

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

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: **Self-adhesive warning labels**.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
    a. Power-transfer switches.
    b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

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

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for **power transfer**.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:
    a. Indoor Equipment: **Self-adhesive, engraved, laminated acrylic or melamine plastic label**. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

b. Outdoor Equipment: **Engraved, laminated acrylic or melamine label**
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

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

END OF SECTION 260553

# SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes: distribution, energy efficient dry-type transformers rated 600 V and less, with capacities up to 1500 kVA. Nominally: 408V 3Ø 60Hz delta input; transformer to output 208V 3Ø 60Hz/ (120V 1Ø). Two dry type transformers are required: one at 100 KVA, (bldg. 300), one at 100 KVA. (EDC)

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

### 1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

## 1.5 CLOSEOUT SUBMITTALS

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

## 1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

## 1.7 DELIVERY, STORAGE, AND HANDLING

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

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Source Limitations: Obtain each transformer type from single source from single manufacturer.

## 2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

   1. Internal Coil Connections: Brazed or pressure type.

2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

## 2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 61 gray.

F. Taps for Transformers 3 kVA and Smaller: None

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature. Chosen

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 -deg C rise above 40-deg C ambient temperature.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor. Chosen

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.

3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

    1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
    2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Manufacturer's standard brackets or floor mounted.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
    1. 51 to 150 kVA: ~55 dBA+0-10
    2. 751 to 1000 kVA: ~70 dBA +0-10
    3. 1001 to 1500 kVA: ~70 dBA +0-10

## 2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws.

## 2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

    1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
    2. Ratio tests at the rated voltage connections and at all tap connections.
    3. Phase relation and polarity tests at the rated voltage connections.
    4. No load losses, and excitation current and rated voltage at the rated voltage connections.
    5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
    6. Applied and induced tensile tests.
    7. Regulation and efficiency at rated load and voltage.
    8. Insulation Resistance Tests:

        a. High-voltage to ground.
        b. Low-voltage to ground.
        c. High-voltage to low-voltage.

    9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

### 3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb.

   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

   1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

## 3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

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

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

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

## 3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

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

D. Tests and Inspections:

   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

## 3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

## 3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

# SECTION 262200 – POWER TRANSFORMERS

## PART 1 - GENERAL

### 1.1 SCOPE OF SUPPLY

Scope of supply shall include furnishing the power transformers as specified herein and on the Power Transformers 2622 Specification Sheets included at the end of this section.

### 1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply include the following:

Placement of transformers on the foundation.

Connection of field circuits to the power station.

External connection of bushings.

Assembly of fire protection systems.

### 1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the power transformers are indicated on the 2622 Specification Sheets included at the end of this section.

### 1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

| **Work** | **In Accordance With** |
|---|---|
| Transformer | ANSI C57 Series and all reference documents<br>IEC Publication 76 and all reference documents |

### 1.5 MATERIALS

The following materials shall be used:

| **Component** | **Material** |
|---|---|
| See attachment data sheets | Engineering Building<br>MV step-up (2000KW) |

| Component | Material |
|---|---|
| See attachment data sheets | Physics Building<br>LV step-down (1000 KW) |

## 1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

| Component | Manufacturer |
|---|---|
| Transformer | ABB (ASEA), Square D (Schneider), GE General Electric, Siemens, SPX-Waukesha |

## 1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

| Tests | In Accordance With | Conducted By |
|---|---|---|
| Factory testing | The latest revision of the applicable ANSI C57 or IEC 76 standards | Factory, manufacturer |

## 1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

| Document Number/Description | Title | Revision |
|---|---|---|
| See attached data sheets | MV 2000 KW Engineering Building | |
| See attached data sheets | LV 1000 KW Physics Building | |

# PART 2 - PRODUCTS

## POWER TRANSFORMERS

### 2.1 GENERAL

This specification is intended for global procurement of outdoor oil-immersed power transformers. The Supplier shall provide a standard design for items within the scope of this specification, but which are not covered in detail by these specifications. The standard design shall be in accordance with accepted industry practices for electrical power generation.

### 2.2 LOADING AND RATING

The current carrying capability shall be limited only by the capacity of the core and coils and not by other components such as winding leads, bushings, and tap changers.

### 2.3 LOAD REJECTION

Generator step-up and unit auxiliary transformers will be directly connected to the generator in such a way that they may be subjected to load rejection conditions that result in an abnormally high voltage from the generator. Therefore, these transformers shall be designed to withstand, as a minimum, the resulting stresses with 1.4 times the rated voltage for 5 seconds, applied at the transformer terminals to which the generator is to be connected.

### 2.4 THROUGH-FAULT WITHSTAND

Transformers furnished under these specifications shall be capable of withstanding, without damage, the mechanical and thermal stresses caused by short-circuit currents limited only by the impedance of the transformer. System impedance shall be considered equal to zero. System prefault voltage shall be equal to the voltage rating of the maximum tap or 1.05 times the principal tap, whichever is greater.

Generator step-up and unit auxiliary transformers shall also be designed to withstand the resulting forces caused by a surge in terminal voltage and fault current contribution from the generator while coasting to a standstill. Unless additional information is specified about the time/current/voltage characteristics of the generator under fault conditions, the following criteria shall be considered the minimum acceptable to account for these factors:

| **Type of Generator** | **Type of Transformer** | **Voltage Overshoot (times rated voltage)** | **Time Duration of Fault (seconds)** |
|---|---|---|---|
| Combustion turbine | Generator step-up | 1.10 | 2 |
| Combustion turbine | Unit auxiliary | 1.25 | 2 |
| Steam turbine | Generator step-up | 1.10 | 2 |
| Steam turbine | Unit auxiliary | 1.25 | 2 |
| Hydro-generator | Either | 1.30 | 2 |
| Diesel GenSet | MV 2000 KW Generator step-up | 1.10 | 2 |
| Diesel GenSet | LV 1000 KW Generator step-down | 1.10 | 2 |

Conformance to these requirements shall be demonstrated by certified short-circuit test data on a transformer with similar core and coil design.

## 2.5 MECHANICAL CONSTRUCTION

Tanks, bases, radiators, covers, junction boxes, and any other attached compartments fabricated from steel shall withstand normal transportation, installation, and service stresses without distortion or damage. The complete tank shall be designed to withstand full vacuum and at least 125 percent of the maximum operating pressure of the oil preservation system furnished. The tank cover shall be sloped or domed to shed water and to assist with the flow of gas bubbles to the gas detector piping and/or relay. Field installation shall not require any welding. The base shall allow skidding or moving on rollers in any direction. Lifting lugs and jacking pads shall be provided for lifting and jacking the completely assembled transformer. The jacking pads must be located near each of the four corners.

The tank shall be designed so that all current transformers can be removed easily without removing the main transformer tank cover.

Holes with automatic drain valves shall be provided at the low point of the bus duct flange enclosures so that condensate and water will not accumulate.

Drawings, nameplates, test reports, and correspondence must use the English language and English units of measure with the metric equivalent in parentheses. The following minimum information must be shown on the transformer outline drawing:

All multiple quantities.

Weights.

Paint color.

Footprint of base.

Valve sizes and types.

77° F (25º C) oil level and low oil level.

Location and detail sketch of ground pads.

Location, cutout size, and open door dimensions of all cabinets.

Bushing and arrester ratings, stud diameters with thread information, and space arrangements with hole patterns.

Location, hole sizes, and detail sketch of jacking, lifting, and pulling facilities. A statement should be made describing which lugs are for lifting the transformer when completely assembled and full of oil.

Distance clearances around the envelope of the transformer that the Purchaser must meet so as not to interfere with operation or maintenance of the transformer and its accessories. Some examples are cooling control cabinet swing door distance, pullout of radiator banks maintenance distances, etc.

## 2.6 CORE AND COILS

Nuts, bolts, and clamps of the core assembly shall be provided with positive locking devices to prevent loosening. For core form transformers, the complete core and coil assembly shall be removable from the tank for repairs.

The core shall be securely grounded to the tank. For core form transformers, the core ground connection shall be detachable and made in an externally located terminal box, accessible without requiring entry into the main tank.

The outermost core steel packets and tie bars shall be divided as needed so that the maximum operating temperature does not exceed the Supplier's standard practice. In no case shall tie bar sections be wider than 3 inches (75 mm) or core packet sections wider than 4-1/2 inches (115 mm).

Core form windings shall be circular. When the coils use paper insulation, it shall be thermally upgraded paper insulation. All windings shall be copper, unless otherwise stated on the 16151 Specification Sheets. When a continuously transposed conductor is used, it shall be epoxy bonded. All windings shall be self-supporting for inward (buckling) and outward (hoop) forces. Windings shall not rely on the core assembly for support to resist inward radial short-circuit forces. Winding capability to resist inward radial forces shall be based on the ability of the conductor to resist forces in a "free-buckling" mode.

## 2.7 DE-ENERGIZED TAP CHANGER (DETC)

The operating handle shall have provisions for padlocking and shall be located no more than 60 inches (1,500 mm) above ground level. The tap position indicator shall be clearly visible from ground level.

## 2.8 LOAD TAP CHANGER (LTC)

When an on load tap changer is specified, it shall be furnished with the arcing contacts housed in separate compartments, designed to prevent any interchange of oil between the compartment and the main tank. Removable bolted covers shall be provided for access to the switch compartment without opening the main tank or lowering the oil in the main tank. A drain valve with sampling device shall be located in the bottom of each oil-filled compartment to provide complete oil drainage. A magnetic liquid level gauge with a vertical face shall be mounted on the side of the oil-filled compartment. A mechanical pressure relief device shall be mounted on the top of the oil-filled compartment. The tap changer shall provide full rated kVA on taps above and below rated voltage. The tap changer shall be designed to provide at least 500,000 operations at the maximum nameplate current rating before contact replacement. When a current limiting series transformer is provided, it must have circular windings and meet all the same criteria as the main core and coil. Series transformers and any internal surge suppression devices must be identified in the proposal.

Equipment for the automatic and manual control of the LTC shall be furnished in a weatherproof compartment mounted adjacent to the tap changer compartment. Access and operation at ground level shall be provided. The following equipment shall be furnished, as necessary, to provide the specified LTC controls:

**Manual Control**

Operating mechanism with motor drive.

Weatherproof compartment with convenience outlet, anti-condensation heater, and light with switches.

Mechanically operated limit switches and stops to prevent overtravel of the drive mechanism beyond the maximum raise and lower positions.

Local position indicator.

Operations counter.

RAISE-LOWER selector switch for manual control.

**Automatic Control**

AUTOMATIC-OFF-MANUAL selector switch.

Voltage testing terminals.

Line drop compensator with adjustable resistance and reactive elements.

Current transformers for line drop compensation.

Voltage regulating relay.

Time-delay relays for first step of a tap position change.

A hand crank for manual operation, with electrical interlock to prevent operation of the motor while the hand crank is being used.

**Remote Control**

REMOTE-LOCAL selector switch.

Remote tap position indicator, selsyn type, for mounting on Purchaser's remote control panel.

Any additional equipment needed for remote/local or automatic/manual control.

Controls shall be provided to hold the LTC in step for operation of three single-phase transformers as a 3-phase bank, if applicable. Means shall be provided for the selection of any single-phase unit to operate as the master or control unit, with the remaining two units to operate as followers. LTC operation shall be blocked for failure of one or both follower units to respond to a tap change signal from the master or for any other out-of-step occurrence. A set of dry alarm contacts shall be provided for an out-of-step condition.

## 2.9 INSULATING OIL

Unless otherwise specified, insulating oil for complete filling shall be furnished with each transformer. The oil shall not contain any polychlorinated biphenyls (PCBs) and shall be Type II, inhibited with 0.15 percent to 0.30 percent by weight of DBPC (2-6 ditertiary butyl paracresol). The transformer main nameplate shall state that the oil is inhibited and contains no detectable PCBs (<1 ppm) at the time of manufacture.

The electrical insulating mineral oil shall be new, unused oil. In addition to meeting the requirements of the applicable national and international industry standards, the oil shall contain less than 25 ppm water and shall test at least 30 kV breakdown strength upon receipt at the delivery point.

Oil shall be shipped by bulk container, such as a tanker or large flexible tank, designed specifically for such use. Shipment in drums is not allowed unless approved by the Purchaser. Each shipping container shall have its oil tested for dielectric integrity prior to being installed in the transformer.

When shipping weight permits, the transformer shall be shipped oil-filled. If the transformer is shipped without oil, then it shall be shipped pressurized with dry air or nitrogen. A pressure vacuum gauge and suitable shutoff valve shall be provided to monitor or add dry air or nitrogen during shipment.

Each transformer and its associated equipment shall be designed and delivered capable of full vacuum filling in the field. The manufacturer's recommended assembly and filling procedures shall be submitted for Purchaser's review prior to shipment.

## 2.10 OIL PRESERVATION SYSTEM

The system shall be designed with an oil temperature range of -13° F to 230° F (-25° C to 110° C). Unless specified, the Supplier will have the option of furnishing a sealed tank system, an automatically maintained inert gas pressure system, or a sealed bladder conservator system. Based on this choice, the appropriate following paragraph shall be applied:

> Sealed Tank System. The system shall include a pressure vacuum gauge and a pressure relief device designed to seal the interior of the transformer from the atmosphere and hold the gas plus oil volume constant within the range of 10 psi (68.9 kilopascals) positive to 8 psi (55.1 kilopascals) negative.
>
> Inert Gas Pressure System. An alarm device with alarm contacts for remote indication of low gas supply shall be furnished. Valves shall be provided to permit purging the gas space and testing the seal on the tank by admitting dry nitrogen under pressure. The gas control equipment, including adequate space for nitrogen bottles, shall be protected by an easily accessible weatherproof enclosure mounted on the transformer. Sufficient nitrogen gas shall be furnished for the initial flushing, filling, and operation. If necessary, used gas cylinders may be returned to the manufacturer at his expense.

Sealed Bladder Conservator System. The system shall prevent air and moisture from coming in contact with the oil through the use of a flexible rubber air cell in the conservator tank. A positive oil pressure must be maintained on all gaskets above the tank cover. A gas detector relay system shall be provided that collects accumulated gases at the high point of the cover. The system shall include a gauge alarm contact and a gas sampling valve at ground level.

## 2.11 BUSHINGS

Transformer bushings above 15 kV class shall be oil-filled, using either the transformer's oil as the cooling and insulating fluid or the bushing's own self-contained supply of oil. Bushings mounted in a vertical position shall have a self-contained oil supply. Oil-filled bushings shall have a sight gauge or other means to indicate oil level.

Bushings above 150 kV BIL shall be condenser type, with capacitance graded layers of insulating material for the purpose of controlling the distribution of the electric field, and shall be equipped with a capacitance or power factor test tap. If the bushing is mounted in a metal enclosed bus duct, the external terminal shall be designed for connection to a bus operating at 221° F (105° C). Gaskets, oil expansion areas, and paper insulation used in the assembly of the bushings shall be suitable for the required operating temperatures. All bushings shall be constructed by using wet process porcelain materials with a homogeneous surface. Porcelain parts of each bushing rated below 450 kV BIL shall be one piece. For "draw lead" type bushings, the transformer outline drawing shall indicate the size, number of strands, and material of the bushing draw lead. Minimum creep distances shall be as specified on the 16151 Specification Sheets using millimeters per rated system voltage, mm/kVL-L.

Outline drawings of each bushing shall be included with the transformer approval drawings. Instruction manuals for each style of bushing shall be included with the transformer instruction manuals.

### 2.11.1 Terminals

Each bushing with a stud type connection shall be furnished with a removable stud-to-pad four hole terminal of sufficient size to continuously carry the maximum current. Aluminum-to-copper bimetallic transition plates shall be furnished. At 230 kV and above, the terminals shall be corona free. System line connections will first connect to the associated surge arrester, if specified.

## 2.12 TERMINATIONS TO THE TRANSFORMER

If a termination compartment is specified, then an air termination compartment should be provided on the tank wall to allow from below.

If a termination flange is specified, then a bolted flange connection to cable, nonsegregated, segregated, or isolated phase bus duct shall be provided as specified. A short flange should be located close to the tank, and a long flange should be located, via a throat, at the end of the bushing top terminal.

## 2.13 SURGE ARRESTERS

Metal oxide station type surge arresters shall be mounted adjacent to the associated bushing with the same minimum electrical clearances as used for bushings. Each arrester shall have a copper connection to a transformer ground pad. Arresters shall have full-capacity copper connections to associated bushing terminals, with all associated hardware, to allow for transmission line connection to the arresters.

## 2.14 NEUTRAL GROUNDING RESISTOR (NGR)

If specified, an NGR shall be mounted on the transformer and shall be of the heavy-duty, outdoor, stainless steel strip type with aluminum enclosure. The resistor assembly shall rest on cap and pin or post type porcelain insulators. Electrical terminals on the resistor shall be insulated bushings. One resistor terminal shall be connected by copper bar bus to the transformer neutral and the other resistor terminal shall be connected by copper bar bus to the transformer ground pad. The grounding resistor enclosure shall be painted the same color as the transformer tank.

## 2.15 CURRENT TRANSFORMERS (CTs)

CTs shall be of the bushing type and shall be mounted internal to the transformer tank. Multi-ratio CTs must have five leads. The continuous current thermal rating factor (TRF) shall be 1.0 minimum. The CT secondary leads shall be fed through the tank to a CT junction block and then brought down to the transformer control cabinet. CT excitation and overcurrent curves shall be submitted for approval.

## 2.16 COOLING EQUIPMENT AND CONTROLS

Integrally mounted, removable cooling equipment shall be provided to maintain the specified transformer rating. An extra set of flanged valves shall also be provided for the future addition of a radiator or heat exchanger.

Manual control switches shall be provided in the control cabinet to allow testing and maintenance of the cooling fans and pumps, and for selecting automatic or manual control. Controls shall provide for changing the sequence of cooler groups. If any of the Supplier's control switches include an off position that prevents operation of any of the cooling equipment, a Form C alarm contact shall be provided for the Purchaser's use.

The cooling equipment control system shall have terminal points for incorporating a normally closed contact from the Purchaser's protective relaying equipment. The open status of this contact shall stop the operation of all cooling equipment. Multiple contact points shall be provided for cooling systems that have redundant, separate power supplies.

On ODAF only transformers, cooling equipment controls shall be arranged so that no single fault in the control circuitry will cause a loss of more than one half of the transformer's megavolt-ampere (MVA) capability.

Cooling fans shall be located a minimum of 24 inches (610 mm) above the base of the transformer. Personnel protection guards shall be placed over fan blades.

If a future forced cooled rating is specified, provisions shall be made on both the transformer and in the control cabinet. The outline, wiring, and nameplate drawings must give sufficient details so that the future equipment can be added in the field. These details include information for the pumps, fans, breakers, relays, and wiring.

## 2.17 COOLING EQUIPMENT MAINTENANCE

To support the removal and maintenance of the equipment without draining oil or removing the transformer from service, the following shall be provided:

Isolation valving for each cooler and/or each pump.

Flange mounted, manually operated shutoff valves with bolts and provisions for padlocking in the open or closed position.

Oiltight covers for each connection to be used when cooling equipment is detached.

Lifting eyes, oil drain, and vents for each cooling unit piping and pump section.

In addition, supports for arresters, conservator tanks, etc., mounted above the cooling equipment must be designed in such a way that no disassembly is required to access the cooling equipment for removal.

## 2.18 ALARMS AND INDICATORS

Alarm indication contacts shall be of the dry type, electrically separate and insulated from the ground, for operation on the specified dc control power system. All alarm and spare contacts and indication leads shall be wired to terminal blocks in the control cabinet for use by the Purchaser. These contacts shall be Form C, one normally open and one normally closed contact, which change status on an alarm condition. The functional description and actuation state of all alarm (and trip) contacts shall be clearly indicated with recommended set points, as applicable, on the Supplier's electrical schematics and interconnection wiring diagrams.

A dial type liquid temperature indicator relay shall be furnished to indicate top oil temperature. In addition to providing visible indication, it shall be equipped with separate alarm and trip contacts, and with a manually resettable maximum temperature indicating hand.

A dial type, hot spot winding temperature indicator relay shall be furnished for the hottest winding. In addition to providing visible indication of the temperature of the winding, each indicator relay shall be equipped with separate alarm and control contacts for the cooling equipment. Each winding temperature indicator relay shall incorporate a current transformer responsive to its associated phase winding current, calibrating resistor, temperature detector element, and heater, all mounted and connected to simulate the hot spot temperature of the winding.

If specified, an additional temperature detection system shall be furnished for the remote logging of oil temperature and hot spot winding temperature. The hot spot devices shall be located in one phase of each winding. Each detector shall have 3 wire or 4 wire shielded cable and shall be either 10 ohm copper at 77° F (25° C) or 100 ohm platinum at 32° F (0° C) as indicated on the 16151 Specification Sheets.

A fault pressure relay and gas detector relay or Buchholz type system (combination gas detector and oil surge) shall be provided that will operate upon gas accumulation and for abnormal rates of pressure rise in the main tank and LTC compartment, if provided. The system shall not be affected by mechanical shock, inrush currents, or impulse voltages. The fault pressure relay system shall provide an auxiliary seal-in relay and reset switch arranged and connected to provide manually resettable lockout function on operation of the primary element. The auxiliary seal-in relay shall be designed for operation on a dc protection scheme, shall include four electrically separate, field convertible contacts for use with remote equipment, and shall be mounted inside the main control cabinet. A local dc indicating light shall be furnished to indicate relay reset required.

An oil flow indicator with alarm contacts shall be provided for each cooling pump.

If specified, a fault gas monitoring system shall be installed and shall be capable of detecting combustible gases and providing visual indication. Alarm contacts shall be provided for remote indication. The fault gas sensor shall be positioned in the tank as recommended by the manufacturer.

Transformer gauges shall be tilted for ease of reading from ground level.

## 2.19 ADDITIONAL ACCESSORIES

The following accessories shall be provided and clearly identified in the proposal:

Resetting mechanical pressure relief device with alarm contact and visual indicator.

Valve for drainage of the oil to within 1 inch (25 mm) of the bottom of the tank, including built-in, capped sampling connection on the discharge side.

Upper filter valve located below the 77° F (25° C) liquid level and on the same wall as the drain valve for the return of filtered oil to the transformer.

One set of single-pole, double-throw (spdt) alarm contacts for liquid level indicator and mechanical pressure relief device.

Two grounding pads on each transformer tank, on diagonally opposite corners.

One bolted clamp type connector for 1/0 AWG (50 mm2) to 300 kcmil (150 mm2) copper conductor for each tank grounding pad.

0.25 inch (6.4 mm) by 4 inch (100 mm) copper bar ground bus connecting each surge arrester and neutral bushing to the ground pads at base level. Exposed copper shall be painted the same color as the transformer.

Nameplates for each major item of equipment and each terminal block in the control cabinet.

One set of special tools for installation, maintenance, and dismantling of the equipment. Tools shall be new and unused and become the property of the Purchaser.

One additional gasket for each gasket located on the transformer, sealed for long-term storage.

## 2.20 CONTROL CABINET

The control cabinet for each transformer shall be intended for outdoor use and shall be dust-tight, raintight, sleet resistant, undamaged by external ice formation, and shall have suitable corrosion protection. All ventilating openings shall be louvered to prevent entrance of rain and shall be equipped with fine mesh dust filters and stainless steel insect screens. The cabinet shall be provided with a gasketed, removable, blank bottom plate that can be drilled or punched in the field. There must be no obstructions beneath the cabinet so that the Purchaser has clear access to connect the incoming cables or conduits.

Control cabinet doors shall have a three-point cabinet type latch with a single handle and shall include provisions for padlocking. Mechanical stops shall be provided for doors and hinged panels. The control cabinet shall be mounted a minimum of 30 inches (760 mm) and a maximum of 78 inches (1,980 mm) above ground. The cabinet and all devices shall be easily accessible from the ground. The cabinet shall not be mounted on the radiators.

A copper grounding bar with terminal screws shall be located in a convenient position in the cabinet near the terminal blocks for grounding of incoming control and power cables.

Indicators, control devices, and terminal blocks mounted in the control cabinet shall have device nameplates.

The control cabinet shall be provided with space heaters capable of preventing condensation of moisture within the cabinet. Space heaters shall receive power from the transformer's internal control power source and shall have a voltage rating twice the energization voltage. Space heaters shall be controlled by an adjustable thermostat, factory set to close on falling temperature at 80.6° F (27° C) (ON) and open on rising temperature at 95° F (35° C) (OFF).

As specified on the 16151 Specification Sheets, a single-phase 15 ampere, grounded convenience outlet shall be mounted inside the control cabinet, including ground fault protection with a test button and separate circuit breaker or fused protection.

## 2.21 DC CONTROL POWER

Electrical devices served from this supply shall not impose any ground connections on the battery. For each dc supply specified, pull-out fuses shall be provided at the incoming terminals to protect downstream devices. A voltage failure relay shall be provided to monitor each dc supply (downstream of the fuses) and shall be provided with one set of Form C alarm contacts wired to field terminals for remote indication of loss of dc power.

## 2.22 AUXILIARY POWER

Auxiliary power will be furnished from external sources as specified on the 16151 Specification Sheets. Main compression type terminals shall be provided for terminating the auxiliary power circuits.

Main circuit protective devices shall be supplied between the main terminals and the auxiliary equipment. Additional branch circuit protective devices shall be supplied on branch circuits.

If two sources of auxiliary power are to be provided, automatic transfer equipment, including an automatic throwover contactor, or automatic transfer switch shall be furnished to transfer load from the normal source to the emergency source upon failure of the normal source.

Ac control power shall be derived from the auxiliary power source(s). Transformation equipment shall be provided as necessary within the control cabinet to supply the specified control power, which includes the space heater and convenience outlet circuits. All ungrounded legs of control power transformers shall be fused.

A voltage failure relay shall be supplied to monitor and alarm on the loss of each auxiliary power source voltage and each control circuit power source voltage. The Supplier shall provide Form C alarm contacts for the Purchaser's use to indicate when any cooling equipment branch circuit protective devices are open and when no other downstream loss of voltage monitoring device alarm contacts are provided.

If the Supplier chooses to furnish motors or other auxiliary equipment designed to operate at a different voltage from the auxiliary power supply, the equipment required to transform the voltage of auxiliary power as supplied to the design voltage of the equipment shall be furnished.

## 2.23 WIRING

Current transformer leads shall be extended into the control cabinet and shall be terminated on shorting type terminal blocks with preinsulated ring type connectors. The secondary leads of the current transformers shall be 100 percent copper wire and 10 AWG (6 $mm^2$) as a minimum. Control cabinet wiring shall be Class B, stranded copper, 14 AWG (2.5 $mm^2$) or larger, with flame retardant, cross-linked polyethylene insulation rated at 600 volts. Splices will not be permitted in control wiring, current transformer leads, or instrument leads, unless screw terminals are provided within a splice box or where current transformer leads must pass through the tank wall.

Terminal blocks, except those used for current transformer circuits, shall be rated at 600 volts as a minimum and shall have screw terminals. Step type terminal blocks are not acceptable. Terminal blocks shall be furnished with white marking strips and without covers. Terminal blocks for circuits above 240 volts ac shall have guards to prevent accidental contact. For every ten terminals used, two or more spare unused terminals shall be furnished on each terminal block for circuit modifications.

Terminal blocks for external connections shall be grouped in the control cabinet for easy accessibility and shall be unrestricted by interference from structural members and instruments. Sufficient space shall be provided on each side of each terminal block to allow an orderly arrangement of all leads to be terminated on the block. On terminal blocks with electrical connections by both the Supplier and the Purchaser, the Supplier's connections shall be made on one side of the block and the Purchaser's connections shall be made on the opposite side.

Cables between the current transformers and accessories and the control cabinet shall be completely enclosed in rigid metallic conduit or tank braces. Exposed cables are not acceptable. Conduit and fittings shall be of intermediate metallic conduit (IMC) or rigid galvanized steel conduit construction and shall be sealed and gasketed. Short lengths of weather-resistant flexible cable may be used for accessories.

## 2.24 PAINT

Metallic surfaces subject to corrosion shall be cleaned and painted with the manufacturer's premium standard cleaning system, paint system, and color, unless otherwise specified on the Power Transformers Specification Sheets. The entire interior of the main tank and the control cabinet shall be painted white for improved inspection visibility. Exposed unpainted parts shall be fabricated of corrosion-resistant materials.

Touchup paint shall be compatible with, and the same color as, the factory applied paint. This additional paint shall be supplied in two separate 1 US gallon (4 liter) containers, properly identified, carefully packed with the accessories, and protected to avoid damage during shipment. A material safety data sheet shall be furnished with the shipping documents.

## 2.25 FACTORY TESTS

Each transformer shall be completely assembled and tested at the factory in accordance with applicable standards using materials and equipment that will be a part of the final assembled unit, specifically, bushings, cooling, and control equipment. At some time during the manufacturing process, all equipment must be mounted to ensure proper fit. This includes, but is not limited to, bushings, the oil preservation system, arresters, neutral grounding equipment, control cabinets, and all cooling equipment.

The Purchaser reserves the right to witness testing and shall be informed in writing at least 30 days prior to the scheduled start date of factory tests so that arrangements can be made for a representative to be present. The Purchaser shall also be notified of the sequence of tests, not less than 10 days prior to testing.

Testing procedures and techniques are to be in accordance with normal accepted industry practice and the appropriate standards.

The transformer shall not be released from the test area until the dielectric, temperature rise, loss measurements, and gas-in-oil test data have been approved by the Purchaser. The Purchaser shall be notified of any unusual event or damage occurring during the fabrication of each transformer and of all tests that do not meet the applicable standard values, manufacturer's standard values, and guaranteed values. The Purchaser reserves the right to inspect such damages or test failures. Corrective measures to overcome such damage or failure shall be subject to acceptance by the Purchaser. Tested and calculated data shall be included in the certified test report. In particular, the calculated hottest spot temperature rises of the windings shall be shown.

To minimize potential damage to the transformer during testing, the resistance, polarity, phase relation, turn ratio, no-load loss, percent impedance, temperature rise (when applicable), and load loss tests should precede dielectric tests. In this sequence, the beginning tests involve voltages and currents, which are usually reduced as compared to rated values, thus tending to minimize damaging effects to the transformer. The dielectric test sequence shall be arranged so that lightning and switching impulse tests precede the power frequency tests, and the final dielectric test performed shall be the induced overvoltage test.

In addition to all tests dictated by and described in the appropriate standards, the following tests and calculations are also required:

Regulation. The regulation of each transformer shall be calculated for unity (1.0), nine-tenths (0.9), and eight-tenths (0.8) power factor lagging by using tested values.

Overexcitation Tests for Generator Step-Up (GSU) Transformers. Each GSU transformer specified herein shall be subjected to a 12 hour overexcitation test. Top oil temperature shall be recorded during the test. Gas-in-oil tests shall be performed before starting and after finishing each 12 hour run.

For units conforming to IEC standards, the unit shall be subjected to 110 percent rated voltage at 100 percent frequency on the input terminals.

For units conforming to ANSI/IEEE standards, the core induction level equal to 110 percent rated voltage, at 100 percent rated frequency, on the output terminals under no-load conditions shall be calculated. This value shall be compared to the core induction level with 105 percent rated voltage, at 100 percent rated frequency, on the output terminals at maximum rated load at 0.8 power factor. Whichever condition results in the greatest value of core induction shall be simulated for this test.

Megger Tests. Insulation resistance and core megger tests shall be performed, with resistance measurements corrected to 68° F (20° C).

Insulation Power Factor Tests. The maximum acceptable value for insulation power factor is 0.5 percent when corrected to 68° F (20° C). Capacitance measurements shall also be made between windings and from windings to ground.

Gas-in-Oil. Dissolved gas-in-oil analysis shall be made before testing begins, before and after temperature rise tests, and after overexcitation tests (totaling four times).

Impedance. The positive and zero sequence impedances shall be measured on all tap positions for units fitted with de-energized tap changers and at both tap extremes, nominal tap, and two other positions (selected by the Purchaser at a later date) for units fitted with LTCs.

Temperature Rise Test. A full temperature rise test shall be performed on one unit of each type and rating specified herein. For GSU transformers having a delta winding, temporary measures shall be instituted to allow for direct individual measurement of the resistance of each phase winding during the temperature rise test shutdowns. This procedure shall be implemented to allow for accurate measurement and calculation of temperature rises and gradients for each winding phase for the purpose of detecting problems within the winding, such as blocked oil ducts or shorted turns. Also, transformers having only a single force cooled nameplate capacity rating (OFAF or ODAF) shall include a temperature rise test at 60 percent of nameplate MVA rating (in addition to the test at 100 percent rating) with all pumps and fans operating, so that temperature rises and gradients needed for the hot spot calculations can be determined. If available, data from a duplicate design may be submitted for review and approval by the Purchaser. The hottest spot temperature rise calculation shall be performed using the "maximum eddy-current watt loss method." Use of empirical hot spot gradient factors to estimate hot spot temperature rises is not acceptable.

Impulse Tests. Lightning impulse and chopped wave tests are required as routine tests on line and neutral terminals of all transformers, except that the chopped wave test is not required on the neutral terminals. Switching impulse tests are required as a routine test on transformer windings rated 300 kV and above, using a test voltage that is approximately 83 percent of the full wave lightning impulse level.

Induced Overvoltage Tests. A Class II, 1 hour, induced overvoltage withstand test with partial discharge measurements shall be performed as a routine test on all transformers regardless of voltage class. The apparent charge shall not exceed 500 picocoulombs (pC) at 1.5 times maximum line-ground voltage. The partial discharge measurements shall be simultaneously recorded in microvolts and shall not exceed 100 microvolts during the test.

Applied Voltage Tests. A short duration (1 minute) power frequency voltage test shall be performed as a routine test on all line and neutral terminals.

Leak Test. An oil leak test shall be performed on each completely assembled transformer, using a test pressure that is 25 percent greater than the normal operating pressure.

Sound Test. The average audible sound level test is required as a design (type) test or if specified on the 16151 Specification Sheets.

Control Wiring. All auxiliary equipment, CT circuits, and control wiring must be tested to verify proper connections. CT ratio and polarity must be checked. The insulation of the control circuits must be verified by applying a power frequency test voltage of 1500 volts for 1 minute or 1800 volts for 1 second with all of the circuits tied together.

Auxiliary Cooling Losses. Fan and pump auxiliary power requirements shall be measured and recorded.

Short-Circuit Tests. The Purchaser reserves the right to request short-circuit withstand tests at any time prior to the completion of final testing of the assembled unit at the contract price adder stated. If short-circuit withstand tests are performed, standard routine factory tests and all additional tests specified shall be repeated following the short-circuit tests. A transformer may be rejected by the Purchaser if it has been materially altered or damaged by the tests so that tested tolerances are exceeded, or if the Supplier cannot prove that the transformer has not been adversely affected by the tests.

Load Current Test for GSU Transformers. Each GSU transformer specified herein that is not being subjected to a full temperature rise test shall be given a load current test that amounts to a standard temperature rise test (including the special procedures for delta windings and hot spot measurements listed under "Temperature Rise Test" above) only at the top MVA rating. The purpose of this test is to confirm that the copper-to-oil gradients are within expected limits and to confirm that no other hot spots in the windings or other metallic pieces are present under load current conditions. An oil sample shall be taken after this test for dissolved gas analysis.

## 2.26 PHOTOGRAPHS

Three sets of color photographs of each core and coil assembly shall be furnished with the instruction books. The photographs shall be taken just prior to placing the completed core and coil assembly into the tank. All photographs shall be 8 inch by 10 inch (200 mm by 250 mm) glossy prints labeled with the transformer manufacturer's name and serial number. Five different views shall be provided as follows: top view, front view, left side view, right side view, and rear view.

Digital photographs in JPEG format may be supplied in lieu of glossy prints.

## 2.27 LOSS EVALUATION

The guaranteed transformer losses shall be stated on the 16151 Specification Sheets and shall be at the reference temperature of 167° F or 185° F (75° C or 85° C), as specified.

The US$/kW values stated on the 16151 Specification Sheets will be used to evaluate this data. The guaranteed losses multiplied by the appropriate US$/kW values will be added to the quoted price and used in determining the lowest evaluated bid.

When a budgeted kW value is given for total losses on the 16151 Specification Sheets, each transformer should be designed for guaranteed losses at or below this level. Bids will be evaluated so that a penalty will be assessed only if the guaranteed losses (at top MVA) exceed the budgeted losses using the stated US$/kW multiplied by the amount that the budgeted losses are exceeded; no bonus will be given if these values are below the budgeted amount.

The contract price will be reduced on any transformer that is tested and found to have losses greater than the guaranteed losses. The price reduction shall be the difference between the actual (tested) losses and the guaranteed losses multiplied by the appropriate US$/kW value. Zero tolerance will be used on tested losses for evaluating penalties. No credit will be given to the Supplier if the tested losses are less than the guaranteed values.

## 2.28 SHIPPING – IMPACT RECORDERS AND DEW POINT TEMPERATURE

The Supplier shall supply and mount impact recorders (in suitable weatherproof enclosures) directly on each transformer prior to shipment. The impact recorder shall provide a permanent record of the magnitude of axial, transverse, and vertical forces to which the transformer is subjected while in transit. For ocean shipment, the impact recorder shall have a time duration long enough for the transformer to reach the installation site.

For units shipped under dry gas, the dew point temperature of the gas in the tank shall be determined immediately prior to shipment.

## 2.29 DESIGN REVIEW

The Purchaser reserves the right to perform an independent review of the Supplier's design. The Supplier shall provide, in a timely fashion, any requested data and information necessary for this review to be performed and shall make the design team available for discussion of the results of this review at a time and location selected by the Purchaser.

## 2.30 INSTALLATION SERVICES

### 2.30.1 Oil Filling

A price adjustment shall be provided for initial oil filling of the transformers in the field. This includes all required pumps, heaters, degassing equipment, oil testing equipment, tools, materials, and labor for hot oil impregnating, vacuum filling, and testing at the site. Prior to filling, the following tests (with acceptable results) must be performed on the oil in each shipping container:

Dielectric strength

Moisture content

Power factor

Interfacial tension

Neutralization number

Unless otherwise specified, the oil shall be included in the price of the transformer, and the field work shall be priced separately.

### 2.30.2 Field Advisor

A price adjustment shall be provided to furnish the services of one or more field service representatives for technical assistance. The service representatives shall be technically competent, factory trained, experienced in the installation and operation of power transformers, and authorized by the Supplier to perform the work stipulated. Duties may include, but not be limited to, the following:

Providing technical advice to assist the erector in installing the transformer and all equipment.

Inspecting and testing the equipment after installation and directing any changes or adjustments required to assure proper operation.

Providing services required as a condition of the warranties.

Instructing the Purchaser's personnel in the operation and maintenance of the transformer and all accessory equipment.

Providing technical direction during startup and initial operation.

Directing the correction of any design or manufacturing defects.

2.30.3 Complete assembly and erection

A price adjustment shall be provided for erection of the transformers. This includes all equipment, tools, materials, and labor for the assembling, vacuum filling, testing, and commissioning of the transformers at the site. Field test reports that include a neatly arranged and bound set of field test data for each transformer shall be provided. Prior to filling, the following tests (with acceptable results) must be performed on the oil in each shipping container:

Dielectric strength

Moisture content

Power factor

Interfacial tension

Neutralization number

All tests and procedures shall be performed as recommended by the transformer manufacturer.

Unless otherwise specified, the oil shall be included in the price of the transformer, and the field work shall be priced separately.

Supplier's field services shall not be included in the lump sum contract amount. Such services shall be provided only as requested on the 16151 Specification Sheets. The Supplier will be paid for the services provided at the rates stated by the Supplier in the proposal; however, payment will not be made for services required to correct design or manufacturing defects, or for any other warranty work.

The daily rates stated in the Supplier's proposal shall be all-inclusive, shall be firm prices not subject to adjustment, and shall include costs associated with work at the jobsite including salary and overhead, local lodging, travel between the jobsite and local lodging, transportation of equipment and vehicles, meals, and miscellaneous expenses. One day of service shall be defined as a normal 8 hour working day. The number of days for which payment will be made will be determined by dividing the number of hours spent at the jobsite by each service representative by 8.

The daily overtime rate stated in the proposal shall be for work performed at times other than the normal working hours established at the jobsite. The rate shall include all costs stated above for straight-time work, as applicable, plus overtime premium, if any. Days of overtime service shall be determined by dividing the total hours of overtime work by 8.

The price stated in the proposal for round trips to and from the jobsite shall include all costs associated with travel to and from the jobsite (except for local travel included in the daily rates), such as salary and overhead, transportation, meals, lodging, and incidental costs.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Preplacement Inspection:
   1. Before placing flowable fill, inspect and complete the formwork installation.
   2. Notify other trades to permit the installation of their work; cooperate with other trades in setting such work, as required.

B. Components:
   1. Seal pipes, manholes and similar components not intended to be filled.
   2. Restrain from floatation.

## 3.2 PLACEMENT

A. General:
   1. Ensure flowable fill fills all cavities required to be filled.
   2. Avoid dislocation of components.
   3. Place in lifts if required to prevent floatation or to limit fluid pressures on formwork, walls, flexible wall pipe, or similar conditions.
   4. Wait 24 hours, minimum, between the start of subsequent placement lifts.

B. Handling:
   1. Handle flowable fill from mixer to place of final deposit in chutes, carts, buggies, conveyors, pumps or crane buckets.
   2. Do not deliver flowable fill by a method with a free fall of more than 3 feet.
   3. Take every possible precaution to prevent separation or loss of ingredients while transporting flowable fill.

C. Rate: Carry on placement at such a rate that flowable fill surfaces not yet to grade or lift shall not have reached their initial set before additional flowable fill is placed.

D. Retempering: Do not add water to the flowable fill once it has left the ready-mix plant.

E. Cold-Weather Operations:
   1. Comply with the recommendations of ACI 306R.
   2. Recommended Protective Measures:
      a. Heating materials.
      b. Providing insulating blankets and windbreaks.
      c. Use heated enclosures.
   3. Do not use frozen materials or materials containing ice or snow.
   4. Do not place on frozen subgrade.

F. Hot-Weather Operations:
   1. Comply with the recommendations of ACI 305R.
   2. Recommended Protective Measures:
      a. Cooling materials.
      b. Placement during cooler hours of the day.
      c. Providing shading and windbreaks.

## 3.3 PROTECTION

A. Cold Weather:
   1. Keep all freshly placed flowable fill from damage due to low temperatures when the mean daily temperature is below 40 degrees F (4.5 degrees C) in accordance with ACI 306R.
   2. Protect flowable fill from freezing until hardened, 36 hours minimum.

B. Loading: Protect flowable fill from construction, traffic or other loads until sufficient strength has been reached.

END OF SECTION 262200

# 262200 Power Transformers

### Instructions for filling out the Power Transformers Specification Sheet

Fill out cells in each worksheet as directed by the text and the project requirements. When finished making selections, print each page using the default page setup, select all sheets together and, print as a group, or print using the report manager.
Use the "Additional Requirements" section to fill in details or needs not covered by the tables. Create additional worksheets for each application type.

The "Selections" tab at the end of the workbook is for internal use only and cannot be modified.

Header and footer information should be edited for the specific project and specification.

| | |
|---|---|
| <Select/enter..> | Blue cells which are blank or contain the text <Select/enter...> contain menus for filling in the cell. |
| 🟨 | Blank yellow cells are to be filled out as dictated by the specific project requirements. |
| 120 VAC | Blue cells which contain specific text show the default or preferred selection, but also contain menus for filling in the cell. |
| Text | Yellow cells which contain specific text show the default or preferred selection, but can also be filled in by the specifier as dictated by the project requirements. As text is entered, use the "ALT-Enter" key combination as a carriage return to insert more than one row of text in a cell. |

## 262200 - Power Transformers Specification Sheet(s)

## 480MV LV Unit Auxiliary Transforn - Technical Requirements

One Required

### Performance and Design Requirements

Diesel Generator service 1,000 KW 480 V 3Ø 60HZ to:408V 3Ø (120V) 60 HZ. Step-down duty

| **APPLICABLE STANDARDS:** | ANSI C57 Series and All Reference Documents |
|---|---|

**RATING**

| Winding | MVA Ratings at 65 C | Rated Voltage | Line BIL (kV) | Neutral BIL (kV) | Connection |
|---|---|---|---|---|---|
| High Voltage; HV | 4800V 1000 KW | 600V | 30 | 30 | Delta |
| Low Voltage1; XV1 | 208V 1000 KW | 600V | 30 | 30 | Res Grd Wye |
| Low Voltage2; XV2 | | | | | Res Grd Wye |

| | | | | |
|---|---|---|---|---|
| **Frequency:** | 60 Hz | **Application:** | Outdoor | |
| **Number of Phases:** | 3 | **Transformer Type:** | Step Down | Three Windings |
| **Cooling Class:** | **ONAN** | **Winding Material:** | 100% Copper | |
| **Vector Group:** | LV lags HV by 30 deg | **Altitude for Design:** | Below 700ft | |
| **Temperature Rise:** | 65 C | | | |
| **Ambient Temperatures of Design:** | | 30 °C Daily Average / 40 °C Max. for Any 24 Hour Period | | |
| **Max. Winding Hot Spot Rise:** | 80°C | | | |
| **Oil Preservation System:** | | Sealed Bladder Conservator | | |
| **Seismic Ground Acceleration Level:** | | Seismic Zone 2 - Low Severity | | |
| **Audible Sound at Max. MVA (dBA):** | | Manufacturer's Standard | | |

**IMPEDANCES (at Rated Voltage, 85 °C Reference Temperature, 2 MVA Base)**

| Windings | Impedance (%) |
|---|---|
| H-X1 | later |
| H-X2 | later |
| X1-X2 | later |

**TAP CHANGERS**

| Regulated Winding | Type | Tap Changer Control | Number of Steps Plus | Number of Steps Minus | Total % Above Rated kV | Total % Below Rated kV |
|---|---|---|---|---|---|---|
| High Voltage; HV | De-Energized | Local Manual | 2 | 2 | 5 | 5 |

## 262200 - Power Transformers Specification Sheet(s)

### 480MV LV Unit Auxiliary Transforn - Technical Requirements

One Required

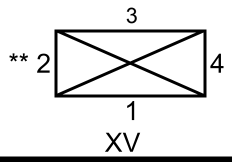
1000 KW 480V 3Ø 60Hz to : 208V 3Ø (120V) 60Hz

**BUSHINGS None**

Termination LUG Details (Later)

| | BIL (kV) | Minimum Porcelain Creep | Termination Compartment? | Termination Flange? | Termination Type | Location | Segment |
|---|---|---|---|---|---|---|---|
| HV | 110 | Mfr Std | No | | | | 3 |
| H0 | 75 | Mfr Std | No | | | | 3 |
| XV1 | 75 | Mfr Std | Yes | Long | Bus to Ground Pad | Wall | 1 |
| XV2 | 75 | Mfr Std | Yes | Long | Bus to Ground Pad | Wall | 1 |

The Physical Arrangement and Terminal Identification Shall Be X1-X2-X3 from Left to Right When Facing XV Side, and H1-H2-H3 from Right to Left When Facing HV Side.



**SURGE ARRESTERS (QTY-One per bushing shown below)**

None

| Location | kV Rating | MCOV Ratings (kV) | Minimum Porcelain Creep | Mounted on Transformer? | Discharge Counters? |
|---|---|---|---|---|---|
| HV Terminals | 15 | 2.55 | Mfr Std | Yes | Yes |

**NEUTRAL GROUNDING EQUIPMENT**

See specification 260526

Later

| Connection Point | Method | Ohms | Amperes | kV | Time Duration | Mounted on Transformer? |
|---|---|---|---|---|---|---|
| X01 | Solid | later | | | | Yes |
| X02 | Solid | later | | | | Yes |

Later

**CURRENT TRANSFORMERS**

| Location Point | Ratio | Accuracy Class | Position on Bushing | Quantity Per Bushing | Total |
|---|---|---|---|---|---|
| | Later | | | 1 | 3 |
| | Later | | | 1 | 3 |
| XV1 Bushings | Later | C400 - ANSI Relaying | Lower | 1 | 3 |
| XV2 Bushings | Later | C400 - ANSI Relaying | Lower | 1 | 3 |
| X01 Bushing | Later | C400 - ANSI Relaying | Lower | 1 | 1 |
| X02 Bushing | Later | C400 - ANSI Relaying | Lower | 1 | 1 |

**PAINT SYSTEM AND COLORS** Later

**Tank and Accessories Color:**
**Painting system:** Manuf Std
**Porcelain Color:**

**POWER SUPPLIES**

| | Nominal Voltage | No. of Source |
|---|---|---|
| Auxiliary Power | 480V Three Phase | 2 |
| Control DC | 125V | 1 |
| Control AC | | |
| Convenience Outlet | | |

## 262200 - Power Transformers Specification Sheet(s)

## 480MV LV Unit Auxiliary Transforn - Technical Requirements

One Required

**LOSS EVALUATION (at rated voltage)**

| | **US$/kW** | **kW** |
|---|---|---|
| No Load Losses (20°C Reference Temperature) | | |
| Load Losses at Maximum MVA Rating (85°C Reference Temp.) | | |
| Auxiliary Cooling Losses at Maximum MVA Rating | | |
| Budgeted Total Losses (No Load + Full Load + Auxiliary)*** | | Sec. 2.1 16151.24 |

*** When a budget loss is given, the design should target this value. Using the US$/kW, total losses (at top MVA) will be evaluated above the budgeted amount.

**ACCESSORIES**

**Resistance Temperature Detector (RTD):** Hot Oil and Hot Spot
**Combustible Gas Detector:** None
**Annunciator Panel:** No

**ANCILLARY EQUIPMENT LOCATIONS**

| **Equipment** | Biotemp (or rqual) NFPA 450.23 | **Segment** |
|---|---|---|
| Conservator Tank Biodegradable coolant oil | | 2 or 4 |
| Control Cabinet | | 2 or 4 |
| Neutral Grounding Resistor | | 2 or 4 |
| Temperature Indicators | | 2 or 4 |
| Oil Level Indicators | | 2 or 4 |
| Ground Pads | | 1 |
| | | N/A |

**ADDITIONAL REQUIREMENTS**

1. O&M Manuals
2. Erection diagram
3. Electrical Cabinet   Geometry details
4. Ground Details
5. Lift instructions
6. Support pad details
7. Load tap changer (manual details)
8. Temperature/level/pressure monitor MFR STD

## 262200 VOLTAGE AND BIL RATINGS

Choose the appropriate BIL from the pulldown menus. If your system voltage is nonstandard, then choose the nearest BIL. Refer to ANSI/IEEE C57.12.00 and IEC 76-3 for relationships of system voltages to BIL levels.

Wye winding neutral-end insulation levels:

1. For fully graded (non-uniform) insulation, the neutral is low, from 45 to 150 BIL, depending on the level of the line-end. Usually used when the neutral is solidly grounded.
2. Fully insulated neutral BILs should be the same as the line-end BIL, also called uniform insulation.
3. It is also acceptable to compromise between the two and insulate the neutral halfway. The BIL should be coordinated with the voltages that can occur between the neutral and ground during normal operation or during fault conditions.

Insulation levels are not assigned when the neutral end is not made accessible through a bushing in the tank. In such cases, the neutral end of the winding should be directly connected to the tank, and the tank solidly grounded. ANSI/IEEE Std 32-1972 (R 1991) includes additional information on neutral insulation, grounding, application, etc.

| **Rated Voltage (kV)** | **Max. System Voltage (kV)** | **BIL Ratings (kV)** | | | |
|---|---|---|---|---|---|
| 1.2 | | **45** | **30** | | |
| 2.5 | | **60** | **45** | | |
| 5.0 | | **75** | **60** | | |
| 8.7 | | **95** | **75** | | |
| 15.0 | | **110** | **95** | | |
| 25.0 | | **150** | | | |
| 34.5 | | **200** | | | |
| 46.0 | 48.3 | **250** | 200 | | |
| 69.0 | 72.5 | **350** | 250 | | |
| 115.0 | 121.0 | 550 | **450** | 350 | |
| 138.0 | 145.0 | 650 | **550** | 450 | |
| 161.0 | 169.0 | 750 | **650** | 550 | |
| 230.0 | 242.0 | 900 | 825 | **750** | 650 |
| 345.0 | 362.0 | 1175 | **1050** | 900 | |
| 500.0 | 550.0 | 1675 | 1550 | **1425** | 1300 |
| 765.0 | 880.0 | **2050** | 1925 | 1800 | |

Values listed in bold are standard values.

## VOLTAGE AND BIL RATINGS (IEC)

Choose the appropriate BIL from the pulldown menus. If your system voltage is nonstandard, then choose the nearest BIL. Refer to ANSI/IEEE C57.12.00 and IEC 76-3 for relationships of system voltages to BIL levels.

Wye winding neutral-end insulation levels:

1. For fully graded (non-uniform) insulation the neutral is low, from 45 to 150 BIL, depending on the level of the line-end. Usually used when the neutral is solidly grounded.
2. Fully insulated neutral BILs should be the same as the line-end BIL, also called uniform insulation.
3. It is also acceptable to compromise between the two and insulate the neutral halfway. The BIL should be coordinated with the voltages that can occur between the neutral and ground during normal operation or during fault conditions.

Insulation levels are not assigned when the neutral end is not made accessible through a bushing in the tank. In such cases, the neutral end of the winding should be directly connected to the tank, and the tank solidly grounded. ANSI/IEEE Std 32-1972 (R 1991) includes additional information on neutral insulation, grounding, application, etc.

Note: The IEC equivalent to BIL is Lightning Impulse Insulation Level (LI).

| **Rated Voltage (kV)** | **BIL Ratings (kV)** | | | |
|---|---|---|---|---|
| 3.6 | 40 | 20 | | |
| 7.2 | 60 | 40 | | |
| 12.0 | 75 | 60 | | |
| 17.5 | 95 | 75 | | |
| 24.0 | 125 | 95 | | |
| 36.0 | 170 | 145 | | |
| 52.0 | 250 | | | |
| 72.5 | 325 | | | |
| 123.0 | 550 | 450 | | |
| 145.0 | 650 | 550 | | |
| 170.0 | 750 | 650 | 550 | |
| 245.0 | 950 | 850 | 750 | |
| 300.0 | 1050 | 950 | 850 | |
| 362.0 | 1175 | 1050 | 950 | |
| 420.0 | 1425 | 1300 | 1175 | 1050 |
| 525.0 | 1550 | 1425 | 1300 | 1175 |
| 765.0 | 1950 | 1800 | 1550 | |

For guidance on selection of insulation, refer to IEC Publication 71-2, the Insulation Coordination Application Guide.

## SURGE ARRESTERS

Basically, the Maximum Continuous Operating Voltage Rating, MCOV, of the arrester is chosen to be near the maximum system voltage, L-G. For example: System is 345 kV ±10%, MCOV=(345 X 1.1)/1.73=219 kV. Choose the 220 kV MCOV arrester which is rated 276 kV.

The attached table is taken from an ABB Selection Guide, and assumes that the maximum system voltage is 1.05 times the nominal. The minimum recommended arrester ratings given meet protective margins used in the industry. However, if accurate temporary overvoltages are known, then a complete analysis can be made. Recommended protective margins given in ANSI/IEEE C62.2 are 20% for full & chopped waves, and 15% for switching surge waves.

The creep distances are specified depending upon the level of contaminants that will be in the atmosphere at the installation site.

Use 16 mm/kV for low creep distance in a lightly polluted environment.
Use 20 mm/kV for standard creep distance in a normal polluted environment.
Use 25 mm/kV for extra creep distance in a heavily polluted environment.
Use 31 mm/kV for extreme creep distance in a very heavily polluted environment.

kV is the rated system voltage, phase-to-phase. For example, the HV bushings on a GSU connected to a 230kV system should have the following standard creep distance: 230kV x 20 mm/kV = 4600 mm (181 inches).

Extra creep is not necessary on bushings enclosed in bus ducts.

Except for 500 and 765 kV systems, arresters are usually mounted on the transformer.

Discharge counters are an accessory that need not be provided unless the client requires.

## VECTOR GROUP

A Vector Group is the IEC shorthand method for indicating a transformer configuration.

The connection corresponding to the high voltage (H) winding is capitalized and the connection(s) corresponding to the other winding(s) use lower case. Y or y indicates a wye or star connection; D or d indicates a delta connection; N or n indicates a neutral connection; and the number following the connection designation indicates the phase shift referenced to the high voltage winding. This number refers to a position on a normal 12-hour clock, with the high voltage reference at 12 o'clock. Therefore, for an ANSI standard transformer, where the low side lags the high side by 30°, the number would be 1. (1 lags 12 by 30° on the clock.)

Examples:

| | |
|---|---|
| YNd1 | The transformer is a two-winding transformer. The high voltage (H) winding is wye connected with a neutral connection and the low voltage winding (X) is delta connected and lags the high side by 30°. Note that this is an ANSI standard transformer. |
| Dyn11 | The transformer is a two-winding transformer. The high voltage (H) winding is delta connected and the low voltage winding (X) is wye connected with a neutral connection and the leads the high side by 30°. |
| YNyn | The transformer is a wye-wye two-winding transformer. |
| YNd1d1 | The transformer is a three-winding transformer. The high voltage (H) winding is wye connected with a neutral connection and the low voltage windings (X and Y) are delta connected and both lag the high side by 30°. |

ANSI Standards specify that the vector relationship for any wye-delta or delta-wye 3 phase transformer shall be so that the low voltage is lagging the high voltage by 30 . This applies regardless of which winding is the delta or wye, and whether the transformer is for step-up or step-down operation.

ANSI Standards state that all single-phase transformers greater than 200 kVA shall have subtractive polarity.

## COOLING CLASS

**ANSI Classes** **(This nomenclature was revised to the IEC format by ANSI in C57.12.00 - 2000 )**

| | |
|---|---|
| OA | Oil to Air, self cooled |
| FA | Forced Air |
| FOA | Forced Oil with Forced Air |
| FOW | Forced Oil with Forced Water (rarely used) |
| FFA | Future Forced Air (industry term, not given in Standards) |

**IEC (and now ANSI) Classes**

| | |
|---|---|
| ONAN | Oil Natural, Air Natural (equivalent to OA) |
| ONAF | Oil Natural, Air Forced (equivalent to FA) |
| OFAF | Oil Forced, Air Forced (equivalent to FOA) |
| ODAF | Oil Directed, Air Forced (slight variation to FOA) |

**Common combinations for dual and triple rated units:**

| | |
|---|---|
| OA/FA | ONAN/ONAF |
| OA/FA/FA | ONAN/ONAF/ONAF |
| OA/FA/FOA | ONAN/ONAF/OFAF |
| OA/FOA/FOA | ONAN/OFAF/OFAF |
| FOA or FOA/FOA | ODAF/ODAF |
| OA/FFA | |

Units below 12 MVA have one or two ratings; 12 MVA and above have three ratings, but there are exceptions. Normally, all transformers 30 MVA and above are triple rated, or straight FOA. An FOA transformer has no self-cooled rating; it should always be near full load.

The specification must state dual or triple rating, but it can be acceptable for the manufacturer to supply his preferred cooling combination.

## 262200 Power Transformers

### Instructions for filling out the Power Transformers Specification Sheet

Fill out cells in each worksheet as directed by the text and the project requirements. When finished making selections, print each page using the default page setup, select all sheets together and, print as a group, or print using the report manager.
Use the "Additional Requirements" section to fill in details or needs not covered by the tables. Create additional worksheets for each application type.

The "Selections" tab at the end of the workbook is for internal use only and cannot be modified.

Header and footer information should be edited for the specific project and specification.

| | |
|---|---|
| <Select/enter..> | Blue cells which are blank or contain the text <Select/enter...> contain menus for filling in the cell. |
| 🟨 | Blank yellow cells are to be filled out as dictated by the specific project requirements. |
| 120 VAC | Blue cells which contain specific text show the default or preferred selection, but also contain menus for filling in the cell. |
| Text | Yellow cells which contain specific text show the default or preferred selection, but can also be filled in by the specifier as dictated by the project requirements. As text is entered, use the "ALT-Enter" key combination as a carriage return to insert more than one row of text in a cell. |

## 262200 - Power Transformers Specification Sheet(s)

## MV Unit Auxiliary Transformers - Technical Requirements

One Required

## Performance and Design Requirements

Diesel Generator service 2,000 KW 480 V 3Ø 60HZ to:4800V 3Ø 60 HZ.

| | |
|---|---|
| **APPLICABLE STANDARDS:** | ANSI C57 Series and All Reference Documents |

**RATING**

| Winding | MVA Ratings at 65 C | Rated Voltage (KV) | Line BIL (kV) | Neutral BIL (kV) | Connection |
|---|---|---|---|---|---|
| High Voltage; HV | 4800V; 2MVA | 5 | 60 | 60 | Delta |
| Low Voltage1; XV1 | 480V/277V | 600V | 30 | 30 | Res Grd Wye |
| Low Voltage2; XV2 | | | | | Res Grd Wye |

| | | | | |
|---|---|---|---|---|
| **Frequency:** | 60 Hz | **Application:** | Outdoor | |
| **Number of Phases:** | 3 | **Transformer Type:** | Step Up | Three Windings |
| **Cooling Class:** | **ONAN** | **Winding Material:** | 100% Copper | |
| **Vector Group:** | LV lags HV by 30 deg | **Altitude for Design:** | Below 700ft | |
| **Temperature Rise:** | 65 C | | | |
| **Ambient Temperatures of Design:** | | 30 °C Daily Average / 40 °C Max. for Any 24 Hour Period | | |
| **Max. Winding Hot Spot Rise:** | 80°C | | | |
| **Oil Preservation System:** | | Sealed Bladder Conservator | | |
| **Seismic Ground Acceleration Level:** | | Seismic Zone 2 - Low Severity | | |
| **Audible Sound at Max. MVA (dBA):** | | Manufacturer's Standard | | |

**IMPEDANCES (at Rated Voltage, 85 °C Reference Temperature, 2 MVA Base)**

| Windings | Impedance (%) |
|---|---|
| H-X1 | later |
| H-X2 | later |
| X1-X2 | later |

**TAP CHANGERS**

| | | | Number of Steps | | Total % Above Rated kV | Total % Below Rated kV |
|---|---|---|---|---|---|---|
| **Regulated Winding** | **Type** | **Tap Changer Control** | **Plus** | **Minus** | | |
| High Voltage; HV | De-Energized | Local Manual | 2 | 2 | 5 | 5 |

## 262200 - Power Transformers Specification Sheet(s)

## MV Unit Auxiliary Transformers - Technical Requirements

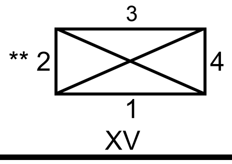
One Required

**BUSHINGS None**

Termination LUG Details (Later)

| | BIL (kV) | Minimum Porcelain Creep | Termination Compartment? | Termination Flange? | Termination Type | Location | Segment |
|---|---|---|---|---|---|---|---|
| HV | 110 | Mfr Std | No | No | Bushing to Arrester | Cover | 3 |
| H0 | 75 | Mfr Std | No | No | Bus to Ground Pad | Cover | 3 |
| XV1 | 75 | Mfr Std | Yes | Long | Bus to Ground Pad | Wall | 1 |
| XV2 | 75 | Mfr Std | Yes | Long | Bus to Ground Pad | Wall | 1 |

The Physical Arrangement and Terminal Identification Shall Be X1-X2-X3 from Left to Right When Facing XV Side, and H1-H2-H3 from Right to Left When Facing HV Side.



**SURGE ARRESTERS (QTY-One per bushing shown below)**

**None**

| Location | kV Rating | MCOV Ratings (kV) | Minimum Porcelain Creep | Mounted on Transformer? | Discharge Counters? |
|---|---|---|---|---|---|
| HV Terminals | 15 | 2.55 | Mfr Std | Yes | Yes |

**NEUTRAL GROUNDING EQUIPMENT**

Later

| Connection Point | Method | Ohms | Amperes | kV | Time Duration | Mounted on Transformer? |
|---|---|---|---|---|---|---|
| X01 | Solid | | | | | |
| X02 | Solid | | | | | |

**CURRENT TRANSFORMERS**

| Location Point | Ratio | Accuracy Class | Position on Bushing | Quantity Per Bushing | Total |
|---|---|---|---|---|---|
| HV Bushings | Later | C800 - ANSI Relaying | Lower | 1 | 3 |
| HV Bushings | Later | 0.3B-1.8 - ANSI Metering | Upper | 1 | 3 |
| XV1 Bushings | Later | C400 - ANSI Relaying | Lower | 1 | 3 |
| XV2 Bushings | Later | C400 - ANSI Relaying | Lower | 1 | 3 |
| X01 Bushing | Later | C400 - ANSI Relaying | Lower | 1 | 1 |
| X02 Bushing | Later | C400 - ANSI Relaying | Lower | 1 | 1 |

**PAINT SYSTEM AND COLORS** Later

**Tank and Accessories Color:**
**Painting system:** Manuf Std
**Porcelain Color:**

**POWER SUPPLIES**

| | Nominal Voltage | No. of Source |
|---|---|---|
| Auxiliary Power | 480V Three Phase | 2 |
| Control DC | 125V | 1 |
| Control AC | | |
| Convenience Outlet | | |

## 262200 - Power Transformers Specification Sheet(s)

## MV Unit Auxiliary Transformers - Technical Requirements

One Required

### LOSS EVALUATION (at rated voltage)

| | US$/kW | kW |
|---|---|---|
| No Load Losses (20°C Reference Temperature) | | |
| Load Losses at Maximum MVA Rating (85°C Reference Temp.) | | |
| Auxiliary Cooling Losses at Maximum MVA Rating | | |
| Budgeted Total Losses (No Load + Full Load + Auxiliary)*** | | Sec. 2.1 16151.24 |

*** When a budget loss is given, the design should target this value. Using the US$/kW, total losses (at top MVA) will be evaluated above the budgeted amount.

### ACCESSORIES

**Resistance Temperature Detector (RTD):** Hot Oil and Hot Spot
**Combustible Gas Detector:** None
**Annunciator Panel:** No

### ANCILLARY EQUIPMENT LOCATIONS

| Equipment | Biotemp (or rqual) NFPA 450.23 | Segment |
|---|---|---|
| Conservator Tank Biodegradable coolant oil | | 2 or 4 |
| Control Cabinet | | 2 or 4 |
| Neutral Grounding Resistor | | 2 or 4 |
| Temperature Indicators | | 2 or 4 |
| Oil Level Indicators | | 2 or 4 |
| Ground Pads | | 1 |
| | | N/A |

### ADDITIONAL REQUIREMENTS

1. O&M Manuals
2. Erection diagram
3. Electrical cabinet   Geometry details
4. Ground Details
5. Lift instructions
6. Support pad details
7. Load tap changer (manual details)

## VOLTAGE AND BIL RATINGS (ANSI)

Choose the appropriate BIL from the pulldown menus. If your system voltage is nonstandard, then choose the nearest BIL. Refer to ANSI/IEEE C57.12.00 and IEC 76-3 for relationships of system voltages to BIL levels.

Wye winding neutral-end insulation levels:

1. For fully graded (non-uniform) insulation, the neutral is low, from 45 to 150 BIL, depending on the level of the line-end. Usually used when the neutral is solidly grounded.
2. Fully insulated neutral BILs should be the same as the line-end BIL, also called uniform insulation.
3. It is also acceptable to compromise between the two and insulate the neutral halfway. The BIL should be coordinated with the voltages that can occur between the neutral and ground during normal operation or during fault conditions.

Insulation levels are not assigned when the neutral end is not made accessible through a bushing in the tank. In such cases, the neutral end of the winding should be directly connected to the tank, and the tank solidly grounded. ANSI/IEEE Std 32-1972 (R 1991) includes additional information on neutral insulation, grounding, application, etc.

| Rated Voltage (kV) | Max. System Voltage (kV) | BIL Ratings (kV) | | | |
|---|---|---|---|---|---|
| 1.2 | | **45** | **30** | | |
| 2.5 | | **60** | **45** | | |
| 5.0 | | **75** | **60** | | |
| 8.7 | | **95** | **75** | | |
| 15.0 | | **110** | **95** | | |
| 25.0 | | **150** | | | |
| 34.5 | | **200** | | | |
| 46.0 | 48.3 | **250** | 200 | | |
| 69.0 | 72.5 | **350** | 250 | | |
| 115.0 | 121.0 | 550 | **450** | 350 | |
| 138.0 | 145.0 | 650 | **550** | 450 | |
| 161.0 | 169.0 | 750 | **650** | 550 | |
| 230.0 | 242.0 | 900 | 825 | **750** | 650 |
| 345.0 | 362.0 | 1175 | **1050** | 900 | |
| 500.0 | 550.0 | 1675 | 1550 | **1425** | 1300 |
| 765.0 | 880.0 | **2050** | 1925 | 1800 | |

Values listed in bold are standard values.

## VOLTAGE AND BIL RATINGS (IEC)

Choose the appropriate BIL from the pulldown menus. If your system voltage is nonstandard, then choose the nearest BIL. Refer to ANSI/IEEE C57.12.00 and IEC 76-3 for relationships of system voltages to BIL levels.

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Note: The IEC equivalent to BIL is Lightning Impulse Insulation Level (LI).

| Rated Voltage (kV) | BIL Ratings (kV) | | | |
|---|---|---|---|---|
| 3.6 | 40 | 20 | | |
| 7.2 | 60 | 40 | | |
| 12.0 | 75 | 60 | | |
| 17.5 | 95 | 75 | | |
| 24.0 | 125 | 95 | | |
| 36.0 | 170 | 145 | | |
| 52.0 | 250 | | | |
| 72.5 | 325 | | | |
| 123.0 | 550 | 450 | | |
| 145.0 | 650 | 550 | | |
| 170.0 | 750 | 650 | 550 | |
| 245.0 | 950 | 850 | 750 | |
| 300.0 | 1050 | 950 | 850 | |
| 362.0 | 1175 | 1050 | 950 | |
| 420.0 | 1425 | 1300 | 1175 | 1050 |
| 525.0 | 1550 | 1425 | 1300 | 1175 |
| 765.0 | 1950 | 1800 | 1550 | |

For guidance on selection of insulation, refer to IEC Publication 71-2, the Insulation Coordination Application Guide.

**SURGE ARRESTERS**

Basically, the Maximum Continuous Operating Voltage Rating, MCOV, of the arrester is chosen to be near the maximum system voltage, L-G. For example: System is 345 kV ±10%, MCOV=(345 X 1.1)/1.73=219 kV. Choose the 220 kV MCOV arrester which is rated 276 kV.

The attached table is taken from an ABB Selection Guide, and assumes that the maximum system voltage is 1.05 times the nominal. The minimum recommended arrester ratings given meet protective margins used in the industry. However, if accurate temporary overvoltages are known, then a complete analysis can be made. Recommended protective margins given in ANSI/IEEE C62.2 are 20% for full & chopped waves, and 15% for switching surge waves.

The creep distances are specified depending upon the level of contaminants that will be in the atmosphere at the installation site.

Use 16 mm/kV for low creep distance in a lightly polluted environment.
Use 20 mm/kV for standard creep distance in a normal polluted environment.
Use 25 mm/kV for extra creep distance in a heavily polluted environment.
Use 31 mm/kV for extreme creep distance in a very heavily polluted environment.

kV is the rated system voltage, phase-to-phase. For example, the HV bushings on a GSU connected to a 230kV system should have the following standard creep distance: 230kV x 20 mm/kV = 4600 mm (181 inches).

Extra creep is not necessary on bushings enclosed in bus ducts.

Except for 500 and 765 kV systems, arresters are usually mounted on the transformer.

Discharge counters are an accessory that need not be provided unless the client requires.

## VECTOR GROUP

A Vector Group is the IEC shorthand method for indicating a transformer configuration.

The connection corresponding to the high voltage (H) winding is capitalized and the connection(s) corresponding to the other winding(s) use lower case. Y or y indicates a wye or star connection; D or d indicates a delta connection; N or n indicates a neutral connection; and the number following the connection designation indicates the phase shift referenced to the high voltage winding. This number refers to a position on a normal 12-hour clock, with the high voltage reference at 12 o'clock. Therefore, for an ANSI standard transformer, where the low side lags the high side by 30°, the number would be 1. (1 lags 12 by 30° on the clock.)

Examples:

| | |
|---|---|
| YNd1 | The transformer is a two-winding transformer. The high voltage (H) winding is wye connected with a neutral connection and the low voltage winding (X) is delta connected and lags the high side by 30°. Note that this is an ANSI standard transformer. |
| Dyn11 | The transformer is a two-winding transformer. The high voltage (H) winding is delta connected and the low voltage winding (X) is wye connected with a neutral connection and the leads the high side by 30°. |
| YNyn | The transformer is a wye-wye two-winding transformer. |
| YNd1d1 | The transformer is a three-winding transformer. The high voltage (H) winding is wye connected with a neutral connection and the low voltage windings (X and Y) are delta connected and both lag the high side by 30°. |

ANSI Standards specify that the vector relationship for any wye-delta or delta-wye 3 phase transformer shall be so that the low voltage is lagging the high voltage by 30 . This applies regardless of which winding is the delta or wye, and whether the transformer is for step-up or step-down operation.

ANSI Standards state that all single-phase transformers greater than 200 kVA shall have subtractive polarity.

## COOLING CLASS

### ANSI Classes (This nomenclature was revised to the IEC format by ANSI in C57.12.00 - 2000 )

| | |
|---|---|
| OA | Oil to Air, self cooled |
| FA | Forced Air |
| FOA | Forced Oil with Forced Air |
| FOW | Forced Oil with Forced Water (rarely used) |
| FFA | Future Forced Air (industry term, not given in Standards) |

### IEC (and now ANSI) Classes

| | |
|---|---|
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| ONAF | Oil Natural, Air Forced (equivalent to FA) |
| OFAF | Oil Forced, Air Forced (equivalent to FOA) |
| ODAF | Oil Directed, Air Forced (slight variation to FOA) |

### Common combinations for dual and triple rated units:

| | |
|---|---|
| OA/FA | ONAN/ONAF |
| OA/FA/FA | ONAN/ONAF/ONAF |
| OA/FA/FOA | ONAN/ONAF/OFAF |
| OA/FOA/FOA | ONAN/OFAF/OFAF |
| FOA or FOA/FOA | ODAF/ODAF |
| OA/FFA | |

Units below 12 MVA have one or two ratings; 12 MVA and above have three ratings, but there are exceptions. Normally, all transformers 30 MVA and above are triple rated, or straight FOA. An FOA transformer has no self-cooled rating; it should always be near full load.

The specification must state dual or triple rating, but it can be acceptable for the manufacturer to supply his preferred cooling combination.

## SECTION 262416 - PANELBOARDS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

### 1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

## 1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

## 1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

## 1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding [minus 22 deg F (minus 30 deg C)] [23 deg F (minus 5 deg C)] to plus 105 deg F (plus 40 deg C).
    b. Altitude: Not exceeding 6600 feet (2000 m).

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

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify WSU no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without WSU written permission.
3. Comply with NFPA 70E.

## 1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.

2. Height: 84 inches (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

   a. Panels and Trim: Galvanized Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

   b. Back Boxes: Galvanized Steel.
   c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

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

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

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

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Ten percent.

L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE.

1. 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. Surge Suppression: Factory installed as an integral part of indicated panelboards.

## 2.3 POWER PANELBOARDS

A. See WSU Construction Design Standard

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

  1. For doors more than 36 inches (914 mm)] high, provide two latches, keyed alike.

D. Mains: Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

  1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
  2. External Control-Power Source: 120-V branch circuit.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. See WSU Construction Design Standard.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: lugs only.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

  1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
  2. External Control-Power Source: 120-V branch circuit.

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

G. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

## 2.5 LOAD CENTERS

A. See WSU Construction Design Standard.

## 2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. See WSU Construction Design Standard.

B. MCCB: Comply with UL 489, to meet available fault currents.

  1. Thermal-Magnetic Circuit Breakers:

    a. Inverse time-current element for low-level overloads.
    b. Instantaneous magnetic trip element for short circuits.
    c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

  2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic Trip Circuit Breakers:

    a. RMS sensing.
    b. Field-replaceable rating plug or electronic trip.
    c. Digital display of settings, trip targets, and indicated metering displays.
    d. Multi-button keypad to access programmable functions and monitored data.
    e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
    f. Integral test jack for connection to portable test set or laptop computer.
    g. Field-Adjustable Settings:

      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.

  4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
  6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
  7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
  8. Subfeed Circuit Breakers: Vertically mounted.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

  1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
  2. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.

## 2.7 IDENTIFICATION

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

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

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

## 2.8 ACCESSORY COMPONENTS AND FEATURES

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

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

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

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

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

## 3.2 INSTALLATION

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

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s) where applicable.
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90” above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

K. Mount surface-mounted panelboards to steel slotted supports 5/8 inch to 1 1/4 inch in depth. Orient steel slotted supports vertically.

L. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

M. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

N. Install filler plates in unused spaces.

O. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

P. Arrange conductors in gutters into groups and bundle and wrap with wire ties**.** Mount spare fuse cabinet in accessible location.

## 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate.

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate.

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

## 3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

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

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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

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

## 3.5 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

## 3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

# SECTION 262726 - WIRING DEVICES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Isolated-ground receptacles.
4. Weather-resistant receptacles.
5. Cord and Plug receptacles.
6. Communications outlets.

### 1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

### 1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

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

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Samples: One for each type of device and wall plate specified, in each color specified.

## 1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

## 1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

## 2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

## 2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from

mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

## 2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, f**eed**through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

## 2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
1. Description:

   a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
   b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

## 2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.7 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

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

## 2.8 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Per Owner, match existing in room or area of work.

B. Wall Plate Color: For plastic covers, match device color.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

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

B. Coordination with Other Trades:

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

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

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

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles **down**, and on horizontally mounted receptacles to the **right**.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

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

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

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

## 3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

## 3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black lettering on face of plate, and durable wire markers or tags inside outlet boxes.

## 3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

# SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

### 1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Molded-case switches.
5. Enclosures.

### 1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

### 1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

1. 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**."

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

   1. Wiring Diagrams: For power, signal, and control wiring.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   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.

C. Field quality-control reports.

   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

## 1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

## 1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to **10** percent of quantity installed for each size and type, but no fewer than **three** of each size and type.
2. Fuse Pullers: **Two** for each size and type.

## 1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

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

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

E. Comply with NFPA 70.

## 1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify [**Architect**] [**Construction Manager**] [**Owner**] no fewer than **seven** days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.
4. Comply with NFPA 70E.

## 1.11 COORDINATION

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

# PART 2 - PRODUCTS

## 2.1 FUSIBLE SWITCHES

A. See WSU construction design standards.

B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with **cartridge** fuse interiors to accommodate **specified** fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

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

D. Type HD, Heavy Duty, Six Pole, Single Throw, **600**-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate **specified** fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, **600**-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate **specified** fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: **Two** NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: **Mechanical** type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.
9. Accessory Control Power Voltage: Remote mounted and powered; **120-V ac**.

## 2.2 NONFUSIBLE SWITCHES

A. See WSU design standards.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, **600**-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, **600**-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, **600**-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: **Two** NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: **Mechanical** type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; **120-V ac**.

## 2.3 MOLDED-CASE CIRCUIT BREAKERS

A. See WSU design standards.

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

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

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and $I^2t$ response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

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

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

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: **Mechanical** type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; **integrally mounted, self-powered** type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: **Circuit-breaker-mounted** communication module with functions and features compatible with power monitoring and control system,
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: **Two SPDT switches** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One **NO** contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with [**electronic**] [**ground-fault**] trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: **Integrally mounted, self-powered**.

## 2.4 MOLDED-CASE SWITCHES

A. See WSU design standards.

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

C. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: **Mechanical** type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: **Two SPDT switches** with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One **NO** contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: **Integrally mounted, self-powered**.

## 2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, [**Type 1**] <**Insert type**>.
2. Outdoor Locations: NEMA 250, **Type 3R**.
3. **Wash-Down** Areas: NEMA 250, **Type 4X**, **stainless steel**.
4. Other Wet or Damp, Indoor Locations: NEMA 250, **Type 4**.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, **Type 7**.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

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

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

## 3.2 INSTALLATION

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

B. Comply with mounting and anchoring requirements specified in section 260529.

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

D. Install fuses in fusible devices.

E. Comply with NECA 1.

## 3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

## 3.4 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections.

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

D. Acceptance Testing Preparation:

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

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

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

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

## 3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
B. Set field-adjustable circuit-breaker trip ranges

END OF SECTION 262816

# SECTION 263213 – 1000 KW DIESEL ENGINE GENERATOR

## PART ONE - GENERAL

### 1.1. SCOPE OF SUPPLY

Scope of supply shall include furnishing the diesel generator as specified herein and on the Diesel Generator Specification Sheets included at the end of this section.

### 1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply include the following:

(Later)

### 1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the diesel generator are indicated on the Diesel Generator Specification Sheets included at the end of this section.

### 1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

| Work | In Accordance With |
|---|---|
| Design and fabrication of the engine generator set | SAE, NFPA, NEMA, IEC 34, AGMA, MIL Std 705C, US EPA Tier 4 |
| Design and construction of pressure boundary piping & vessels | ASME Code for Power Piping, B & PV sections: I, VIII, IX. ANSI/ASME B31.1 - Power Piping |
| Design and construction of flanges | ANSI B16.5 |
| Design and construction of small bore connections 2 inches (50 mm) and less | ANSI B16.11 |
| Design and construction of radiator and fan | HEI - Heat Exchange Institute, TEMA - Standard of Tubular Exchanger Manufacturers Association, Class C |

| Work | In Accordance With |
|---|---|
| Fuel oil storage tank | NFPA, UL, API |
| Design and construction of electrical components | NEMA, IEEE |

## 1.5 MATERIALS

The following materials shall be used:

| Component | Material |
|---|---|
| | |

## 1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

| Component | Manufacturer |
|---|---|
| Diesel engine generator set | Caterpillar, Onan, Kohler, Cummins, Generac |
| Radiators | Smithco Engineering, Americool, O&M Manufacturing, ABB, or Coiltech |
| Governor | Woodward Model 2301A, Woodward 701A, Woodward Model 723, or equal |

## 1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This Quality Assurance Program Planner testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

| Tests | In Accordance With | Conducted By |
|---|---|---|
| Purchaser | ASME Code for Power Piping, ANSI/ASME B31.1 - Power Piping | Supplier |
| Shop performance tests | ISO and manufacturer's standard QA Test Plans and as specified herein | Supplier |
| Field performance tests | After field installation, the Purchaser will test the completely assembled equipment for compliance with all performance requirements specified herein. Testing shall be done in accordance with the applicable ISO standards. | Purchaser |

## 1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

| Document Number/Description | Title | Revision |
|---|---|---|
| None Identified | | |

# 2 PART TWO - PRODUCTS

## 2.1 GENERAL

This article covers the design, performance, and construction requirements for all diesel generator units in which the diesel engine and generator are installed on a common steel base.

The following definitions define the duty type specified on the Diesel Generator Specification Sheets included at the end of this section. Load factor shall be defined as the sum of the products of "percent of time x percent of load." "Percent of time" is defined as "time at specific load/total operating time" and "percent of load" is defined as "specific load/rated load." Extended idling time and the time when the generator set is not operating do not enter into the calculation for load factor:

Continuous Duty. Rated kW and kvar output available without varying load for an unlimited time. The unit shall be suitable for a 100 percent load factor.

Prime Duty. Rated kW and kvar output available with varying load for an unlimited time. The unit shall be suitable for a 70 percent load factor.

Standby Duty. Rated kW and kvar output available with varying load for the duration of the interruption of the normal source power. The unit shall be suitable for a 60 percent load factor.

The diesel generator unit shall meet the operating conditions and equipment sizing criteria as specified herein and on the Diesel Generator Specification Sheets.

## 2.2 PERFORMANCE

The diesel generator set shall be designed to operate reliably under the conditions specified on the Diesel Generator Specification Sheets.

The diesel generator set shall consist of a diesel engine directly coupled to a generator and shall have a unit control panel. The equipment shall be mounted on a common steel base and, housed in a required level 2 weatherproof acoustical enclosure designed to meet the requirements specified on the Diesel Generator Specification Sheets. The unit shall be furnished with all auxiliary equipment required to locally operate it. When feasible, all transformers, motor starters, and electrical control equipment required for operation of the unit as specified in this article shall be furnished and mounted within the confines of the steel base. All interconnecting piping and wiring for equipment mounted on the steel base shall be factory installed.

A two-hole bronze grounding pad attached to the generator frame shall be supplied adjacent to the main lead terminal housing.

A two-hole grounding pad shall be placed on each end of the diesel generator skid frame.

## 2.3 DESIGN CONDITIONS

The diesel generator shall be designed and constructed in accordance with the conditions specified herein.

The generator with associated drive, radiator, exhaust silencer, and accessory equipment will be located as specified on the Diesel Generator Specification Sheets.

### 2.3.1 Starting and Loading

The unit shall be capable of being started, synchronized to the system, and loaded to the full rating of the unit without dependence upon ac auxiliary power for a minimum of 5 minutes. The unit shall be capable of accepting load in accordance with the specified loading sequence shown on the Diesel Generator Specification Sheets. The voltage and frequency variations shall remain within the tolerances specified on the Diesel Generator Specification Sheets.

### 2.3.2 Fuel Storage and Supply System

A complete fuel supply system including a fuel oil sub-base belly mounted storage tank, fuel oil transfer pumps, all valves and piping, and all fuel control level and flow metering and sensor devices shall be furnished. The day tank shall be sized to operate the diesel generator at full load for the time specified on the Diesel Generator Specification Sheets. If an external storage tank is required due to capacity needs, that fuel tank shall be located remote from the generator set.

The day tank shall be equipped with a gauge glass to show fuel level inside the tank and the required instrumentation shall be in accordance with the Diesel Generator Specification Sheets. Fuel filling operations shall not disturb the accuracy of the level indication system.

The day tank shall be provided with the following minimum connections:

One full sized fuel oil supply.

One full sized fuel oil return.

Vent.

Fill. (with local spill capture feature)

Drain.

Two connections for illuminated level gauge glass.

Level sensor monitor/alarm, & percent filled features

### 2.3.3 Control and Operation Requirements

The unit shall be controlled as specified on the Diesel Generator Specification Sheets. Unit performance and alarm management external communication digital messaging, and limited command/control features shall be provided.

## 2.4 DIESEL ENGINE CONSTRUCTION

A turbocharged diesel engine with an aftercooler, designed for operation for the fuel and ambient conditions specified on the Diesel Generator Specification Sheets, shall be provided. The engine shall be sized to provide the minimum required net generator output kVA at the rpm and at power factor specified on the Diesel Generator Specification Sheets. The engine shall be furnished with all accessories required for a complete unit and shall be the manufacturer's standard for this service.

### 2.4.1 Engine Cooling System

The coolant water radiator type shall be as specified on the Diesel Generator Specification Sheets. The engine cooling system shall be filled with a permanent antifreeze mixture with rust inhibitor. A jacket water electrical heater shall be furnished and sized to maintain jacket water at 100° F (38° C) with a winter ambient temperature as specified on the Diesel Generator Specification Sheets. The jacket water heater shall be thermostatically controlled and shall be monitored and alarmed.

The engine shall also be equipped with an engine mounted jacket water pump and thermostat to properly control engine temperature.

### 2.4.2 STARTING SYSTEM

For engines using an electric starting system, the starting system shall be complete with wet cell batteries, battery charger, battery rack, and cables. The battery shall be sized to provide the specified number of starts and cranking time at firing speed at any ambient between the specified minimum and maximum design ambient temperatures. An electrical heat pad for the battery shall be provided to keep the battery in a ready state at the specified minimum ambient temperature. All parameters are provided on the Diesel Generator Specification Sheets. The charger shall be furnished with ground detection, charger trouble alarm, and an automatic equalize timer for fast recharge. The charger shall be suitable for operation at the Purchaser-provided input power conditions and shall alarm on loss of power. Recharge time for a fully discharged battery shall be as specified on the Diesel Generator Specification Sheets. For engine generator sets rated 750 kW and above, a redundant electric starting motor shall be provided.

For engines using an air starting system, an air starting system shall be furnished complete with air starting motors or direct compressed air injection into the cylinders, compressed air storage tank, ac electric motor driven air compressor, air-cooled engine driven air compressor, air filters, air dryers (as required), and all control, alarm, and instrumentation devices/components. (Not Chosen)

The air starting system shall be sized to provide the specified number of starts and cranking time at firing speed at all ambient conditions between the specified minimum and maximum design ambient temperatures without air compressor operation being required. The electric motor driven air compressor shall provide the normal source of air to recharge the compressed air storage tank. The air-cooled engine driven air compressor will serve as a backup when no electric ac power is available. Each air compressor shall be capable of recharging the air storage tank in 30 minutes. (Not Chosen)

The air-cooled engine air compressor shall be provided with an electric direct current motor starting system. The batteries shall be capable of maintaining the cranking speed recommended by the engine manufacturer through a 6 minute cycle (15 seconds cranking, 15 seconds rest, 12 consecutive cycles). The batteries shall be mounted in a storage rack. An automatic battery charger of the self-regulating type with alarm contacts for loss of power and trouble shall be furnished. The batteries and battery charger shall be mounted on the same base as the engine and air compressor. (Not Chosen)

### 2.4.3 Combustion Air Intake.

The combustion air intake with filtration and noise suppression shall be in accordance with the Diesel Generator Specification Sheets.

### 2.4.4 Fuel System

A fuel management system shall be furnished to regulate fuel flow to maintain constant rated speed regardless of load variations.

The monitored and alarmed fuel system shall include an engine governor, fuel metering equipment, actuator, twin isolable strainers, engine driven fuel pump, relief valve, filters, and fuel cutoff valves. A day tank shall be provided as specified herein under the article titled Fuel Storage and Supply System.

An electric dc motor driven startup fuel priming pump shall be provided if required by the manufacturer's design for "black start" of the diesel generator set.

### 2.4.5 Lubrication System

The monitored and alarmed lubrication system shall provide positive lubrication for the high-speed bearings and main gears, and pressure jets for secondary gears. The remaining bearings and gears may be splash lubricated.

Equipment for the system shall include an engine driven main oil pump, system pressure regulator, engine block heater, full flow oil filter set, heat exchanger, pressure and temperature sensing devices, indicators, and monitoring circuits.

The lube oil dual path tubular heat exchanger shall be designed to use the engine coolant as the cooling medium. The heat exchanger shall be mounted on the unit base.

An electric dc motor driven prelube oil pump shall be provided if required by the manufacturer's design for "black start" of the diesel generator set.

Whenever ~~a~~ an atmospheric pressure lube oil makeup tank is specified on the Diesel Generator Specification Sheets, the Supplier shall provide a 30 gallon (113 liter) (minimum size) lube oil makeup tank (with stand, if necessary) suitable for gravity feed to the engine and complete with pipe and fittings, level sensors with alarms, a one-way check valve, and an oil level regulator.

Provisions shall be made to facilitate the removal of used engine oil from the unit for discharge into drums.

If required by the manufacturer's design, The Supplier shall furnish thermostatically controlled and alarmed lube oil heater(s) and lube oil circulation pump(s) to keep the diesel engine in a ready state during cold weather, based on the minimum specified design ambients.

### 2.4.6 Exhaust System

The exhaust system shall consist of an exhaust silencer, expansion joints, Interconnecting ductwork, and the necessary amount of exhaust pipe to allow the unit to be exhausted outdoors. The silencer shall be designed to limit the noise to the levels specified on the Diesel Generator Specification Sheets.

2.4.7 Unit Controls

Unless specified otherwise herein, the Diesel Generator synchronous speed governor shall use electronic digital logic and shall be Woodward Model 2301A, Woodward Model 701A, Woodward Model 723, 501A or equal. Loading and synchronizing of the diesel generator shall be with a Woodward Digital Synchronizer and Load Control (DSLC) module or equal. External devices and software interface required for setting and programming the governor or load control shall be furnished by the Supplier. The Supplier shall provide the engineering, software, and settings. The Supplier shall submit the calculations for review by the Purchaser.

The control system features shall include the following:

Load sharing, if specified on the Diesel Generator Specification Sheets. The equipment shall be capable of isochronous load sharing with other parallel generators:

Automatic generator loading and unloading shall support bumpless load transfer.

Automatic Transfer Switch communication and coordination capability: Any transfer switch that detects Utility power failure or degraded Utility bad power will command signal the new 1000 KW GenSet to start and then deploy emergency power to each/all paralleled ATS switches. Refer to electrical Drawing E-102 that identifies the ATS assignment numbers and destinations served by the 1000 KW GenSet. That ATS connection to the deployed emergency GenSet will be retained until the ATS power condition monitoring circuits determine that utility incoming power has been reliably restored within allowable limit setpoint conditions. After power restoration parameters are satisfied, and then initiate a closed transition sequence to reconnect loads to utility power resources. No parallel external electrical connected GenSet operation design is contemplated.

Each of several ATS units with their sensor circuits and their time sequencing circuits will be equipped with a control output signal, any one signal (or all simultaneously) paralleled signals will command start the 1000 kW GenSet.

Design and deploy a Sequence of Event (SOE) time history circuit feature that monitors all/any ATS command events (or for all/any scheduled maintenance calls) for GenSet starts to resolve realtime start event conditions in ~one millisecond intervals. Retain all SOE records for ~ one year.

The automatic synchronizing scheme for the new 1000 KW GenSet shall be designed to select and synchronize the diesel generator across each of two generator mounted 1200AF (1200AT) and another 1200AF (1200AT) 480V 3Ø 60Hz circuit breakers furnished with the new equipment identified on the Diesel Generator Specification Sheets:

Automatic Transfer Switch(es) initiate call for GenSet.

Dead bus closing system.

VAR/power factor control, if specified herein.

Engine speed control.

Isochronous or droop mode.

Actuator as required by the application.

Load bank test alignment capability, if specified herein.

The control system shall be designed for black start of the 1000 KW diesel generator. It shall be assumed that utility restoration ac power will not be available until approximately 5 minutes after the engine GenSet has been deployed.

All motors starters, cabling, and contactors for protected electric equipment provided by the Supplier shall be furnished terminated and tested.

### 2.4.8 Diesel Generator Unit Local Control Panel

Electrical control and metering equipment for the diesel generator shall be furnished, mounted, and wired on the unit control panel. If mounted on the diesel generator steel base, the local unit control panel shall be mounted with resilient mounts. The local unit control panel shall be completely enclosed at the front, rear, top, and both sides. A hinged front panel shall be provided to allow for maintenance of the controls and instruments. Equipment furnished shall be in accordance with the Diesel Generator Specification Sheets. Analog monitoring and digital alarm circuits for the buyer's external field circuits shall be brought to terminal blocks or conditions.

If specified or allowed on the Diesel Generator Specification Sheets, the Supplier may propose hardened industrial Panel View touchscreen operator interface panels to achieve the specified control and alarm functions for the local control panel. The interface monitoring and alarm panel shall provide operator access to all information, alarms, and controls for operation of the diesel generator and ancillary systems. It shall include, but not be limited to, voltages, currents, kW, kvar, engine parameters such as cylinder and exhaust temperatures, oil pressure, and temperature, coolant pressure, and temperature.

All operator interface command functions, except screen paging, shall be designed for two-step operation. The operator shall be required to make one touchscreen action to select the function to be performed and a touchscreen action to execute the function. Seller shall identify his standard serial data monitoring top/IP, models external monitoring and alarm capabilities. Seller shall identify features as a mandatory alternative offering.

### 2.4.9 Diesel Generator Unit Remote Control Interface

The requirements and equipment supply for remote control of the diesel generator unit are specified on the Diesel Generator Specification Sheets.

### 2.5 Generator Construction

The unit shall be in accordance with the applicable standards specified in Article 26 3213 1.4, and shall include a synchronous wye connected generator designed for direct connection to the engine previously specified. Generator construction shall include damper windings and shall conform to the applicable standards for synchronous generators, salient-pole type. The generator and exciter shall be provided with an open dripproof, fully guarded, screen protected enclosure. The minimum rated capacity shall be at least equal to or greater than the maximum engine overload capacity and at rated power factor load. The Supplier shall guarantee satisfactory operation at maximum capacity continuously and at all other levels of reduced loading. The Supplier shall design and furnish any required equipment, monitoring and protective interlock devices, or materials to ensure that the generator provides voltage, current, and frequency within the allowable tolerances of all connected loads being supplied.

The insulation system of the armature and field windings may be or Class H [356° F (180° C) hot spot] or Class F [311° F (155° C) hot spot]. Based upon a 104° F (40° C) ambient temperature and a 50° F (10°C) low.

(10° C) hot spot allowance, the temperature rises when measured by resistance shall not exceed the following:

| Duty Basis | Class F [311° F (155° C) hot spot] | Class H [356° F (180° C) hot spot] |
|---|---|---|
| Standby | 266° F (130° C) | 302° F (150° C) |
| Prime | 221° F (105° C) | 257° F (125° C) |
| Continuous | 176° F (80° C) | 221° F (105° C) |

A vacuum pressure impregnation (VPI) process shall be utilized on form wound stator windings.

The manufacturer shall provide a stator coil pitch, coil distribution, and skew to minimize the total harmonic distortion (THD) to less than 5 percent.

The armature and field windings shall be coated with a fungus resistant resin.

The generator shall be provided with the specified exciter in accordance with the Diesel Generator Specification Sheets. It shall enable the generator to sustain 300 percent of rated full load current for 10 seconds during a fault condition.

An automatic voltage regulator with 3-phase sensing shall be provided. The regulator shall have overexcitation protection. A static voltage adjuster shall be provided for use with an automatic synchronizer.

All external control and auxiliary power wiring connections shall be made at terminal blocks at one location on the unit.

The generator neutral shall be closed. Space heaters shall be furnished inside the generator enclosure. Space heater capacity shall be as required to maintain the internal temperature within the generator enclosure above the dew point when the generator is idle. Space heaters shall be rated for the appropriate conditions. The space heater rated voltage shall not be less than 1.5 times the applied voltage. The Supplier shall provide all internal space heater wiring and branch circuit protection. A complete space heater control thermostat and temperature alarm sensor system shall be furnished by the Supplier as an integral part of the diesel generator unit. The space heater control system shall include an interlock with the diesel generator unit so that the heaters are de-energized when the generator is operating. An adjustable thermostat shall also control the space heater.

## 2.6 Electrical Equipment Construction

Except as otherwise specified, all necessary electrical equipment and wiring associated with the unit shall be provided and factory installed on the unit and shall be included in accordance with manufacturer's NEC-70 compliant standard practices.

2.6.1 Unit Base Junction Box

A single diesel generator unit base junction box complete with antecedent low voltage motor control center circuit wiring to all manufacturer's motors heaters lighting and terminal blocks shall be furnished at one location for all equipment located on the diesel generator base. Terminal blocks shall be provided for all motor power circuits, space heater circuits, monitoring and control circuits, current transformers, and potential transformers. The generator output terminals may be housed in a separate box. The generator output terminals shall be separated from the other circuits in the terminal box by a metal barrier if they are in the same box as the balance of terminations.

All wiring and raceway required between devices mounted within or on the diesel generator unit base shall be factory installed.

2.6.2 Neutral Grounding Equipment

The generator shall be furnished with the specified neutral grounding equipment listed on the Diesel Generator Specification Sheets.

2.6.3 Motors

All motors furnished under this specification for the diesel generator shall be in accordance with the requirements of the Low Voltage Induction Motors specification or the Single-Phase Motors specification.

Motors located within the confines of the unit steel base shall be grounded in the motor terminal housing.

2.6.4 Nameplates

Engraved nameplates shall be furnished for the front of each unit. The Purchaser will provide nameplate inscriptions during detailed design.

2.6.5 Wiring and Wiring Diagrams

The Supplier shall provide internal cabinet wiring, connections, and diagrams in accordance with the requirements of the following articles:

Cabinet Wiring. All wiring used within the cabinet connected to external GenSet sensors, switches, alarms, powered equipment and to the owner's remote control external locations shall be installed and tested at the factory.

All wiring shall be neatly and carefully installed in wiring gutters or raceways. All power supply circuits shall be provided with suitable isolation/electrical protection means consisting of either fuses or circuit breakers.

A continuous bare copper ground bus, with a compression or clamp type connector at one end, shall be provided in each cabinet. All cabinet equipment requiring grounding shall be connected to this ground bus.

Diagrams. The Supplier shall furnish schematic, connection, interconnection, one-line, and three-line diagrams. The drawings shall be in accordance with the exchange of engineering information agreed to during detailed design conferences.

The instrumentation and control sensor switches, display components, transmitters/transducers and controlled equipment shall be documented in a Process and Instrument Diagram with its corresponding instrument index (tags, process description, PLC identity, circuit NOS, set point data, et.a1.

#### 2.6.6 Instruments and Devices

Equipment furnished shall be in accordance with the Diesel Generator Specification Sheets.

### 2.7 Bus Duct

Where bus duct is specified on the Diesel Generator Specification Sheets for power conductors, the Supplier shall coordinate with the bus duct vendor to ensure that all materials required to complete the interface are provided by the bus duct vendor.

### 2.8 Enclosures

If specified on the Diesel Generator Specification Sheets, an enclosure for the diesel generator set shall be furnished in accordance with the design conditions, environment, and sound attenuation specified. When possible, a pitched roof shall be provided to prevent the accumulation of moisture and debris. Paint characteristics shall be in accordance with the Diesel Generator Specification Sheets.

All the doors on the enclosure shall be located in areas to allow ease of maintenance on the diesel generator set and allow access to and visibility of instruments, controls, engine, gauges, etc. Doors shall be lockable, gasketed, and shall be mounted with corrosion-resistant hardware. Doors to nonwalk-in enclosures shall be easily removable and mounted on lift-off hinges.

### 2.9 Tests

The diesel generator unit shall be tested in accordance with the requirements stated herein and the applicable standards.

#### 2.9.1 Factory Test

All factory and site acceptance test plan steps, results objectives, and completion data shall be captured within the manufacturer's Quality Assurance Program submittal documentation.

The drive and generator shall be completely factory assembled and tested by the manufacturer to prove that they are assembled correctly, and shall be capable of meeting the net generator output kVA rating. All other components and support systems shall be thoroughly inspected by the Supplier prior to shipment. All control systems shall be tested to verify correctness of assembly and operation, applicable high potential tests, and applicable standard tests. The integrity and proper connection of all electrical circuits shall be verified/ and demonstrated.

The Owner shall be notified concerning TES cycle Quality Assurance Plan activities 10 working days in advance of test dates. Provide timely invitation to witness tests.

### 2.9.2 On-Site Testing

Furnish a continuous on site four (4) hour 100% full load "Load Bank" test. Test to be conducted during normal business hours. 0830-1700 hours, Monday through Friday. WSU to be provided with a seven (7) day notice. WSU shall witness test.

### 2.9.3 Type Tests and Certificates

Where type tests and certificates are specified in Article 26 3213 1.7, Supplier shall perform the type tests as required and in accordance with all the applicable standards.

## 3 PART THREE - EXECUTION

Not Applicable.

END OF SECTION 263213

## 16032 Diesel Generator

### Instructions for filling out Diesel Generator Specification Sheet

Fill out cells in each worksheet as directed by the text and the project requirements.
When finished making selections, print each page using the default page setup, select all sheets together, and print as a group, or print using the report manager.
Use the "Additional Requirements" section to fill in details or needs not covered by the tables. Create additional worksheets for each application type.

The "Selections" tab at the end of the workbook is for internal use only and cannot be modified.

Header and footer information should be edited for the specific project and specification.

| | |
|---|---|
| <Select/enter..> | Blue cells which are blank or contain the text <Select/enter...> contain menus for filling in the cell. |
| 🟨 | Blank yellow cells are to be filled out as dictated by the specific project requirements. |
| 120 VAC | Blue cells which contain specific text show the default or preferred selection, but also contain menus for filling in the cell. |
| Text | Yellow cells which contain specific text show the default or preferred selection, but can also be filled in by the specifier as dictated by the project requirements. As text is entered, use the "ALT-Enter" key combination as a carriage return to insert more than one row of text in a cell. |

## 1000 KW Diesel Generator Specification Sheets
## (Page 1 of 7)

### Interface Points and Scope of Work

| | |
|---|---|
| The equipment and materials to be furnished shall include, but not necessarily be limited to, the following major items: | |
| Diesel generator and ancillary equipment | Yes |
| Exhaust silencer and piping between the silencer and the engine | Yes |
| Intake air filter and associated piping between the filter and the engine | Yes |
| Two Generator breakers: One 1200AF (1200AT); and one 1200AF (1200AT). | Yes |
| Bus between generator breaker and the generator | Yes |
| Fuel storage belly tank 1,100 GAL storage | Yes |
| Radiator | Yes |
| Battery for cranking and controls with accessory charger & battery stands | Yes |
| Protective relaying and alarms; control HMI display panel(s) | Yes |
| Compressed air starting equipment | Yes |
| Weatherprooof enclosure | Yes |
| Vibration isolators | Yes |
| Motor controls and starters | Yes |
| | |
| | |
| | |
| | |
| Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Supplier in accordance with the following: | |
| All necessary connections for the Purchaser's piping and instruments | Yes |
| All necessary instrument, power, and control wiring and raceways integral to any equipment furnished under these specifications, wire and term block identifications | Yes |
| All special tools or lifting lugs for offloading | Yes |
| All special tools required for erection of the equipment. Erection tools shall remain th property of the Supplier. All shipping costs to and from the jobsite shall be at the Supplier's expense. | Yes |
| Bolting materials between equipment furnished and the Purchaser's structural steel | Yes |
| Leveling blocks, soleplates, thrust blocks, matching blocks, and shims | Yes |
| All nuts, bolts, gaskets, special fasteners, backing rings, etc., between components and equipment furnished under these specifications | Yes |
| Hangers and accessories for piping furnished under these specifications | Yes |
| All piping and ductwork integral to or between any equipment furnished under these specifications, except as otherwise specified | Yes |
| A Quality Assurance Program test Plan & sign-offs; with MTR data | Yes |
| A complete operations and a maintenance manual with software | Yes |
| The following items of work will be furnished by the Purchaser: | |
| Miscellaneous piping and tubing between equipment | Yes |
| Permanent electric wiring to connect equipment terminal boxes to plant electrical system | Yes |
| Lubricants, coolants, and fuels for operation; air and oil filters | Yes |
| Solvents and cleaning materials | Yes |
| Grouting materials and the placing thereof | Yes |
| Operating personnel for startup and tests | Yes |
| | |
| | |

# 1000 KW Diesel Generator Specification Sheet(s)

(Page 2 of 7)

| **Performance Guarantees** | | | |
|---|---|---|---|
| **Diesel Generator Ratings**<br>**Emergency Power Duty 1000 KW** | The diesel generator rating shall be the sum of the specified "minimum kW" load and diesel generator parasitic loads. | | |
| **Description** | **Duty Type** | **Minimum kW** | **Power Factor** |
| Continuous load | Standby duty | 1,000 | 0.8 lag |
| Manufacturer to state achievable load turndown ratio operations data | | | 0.8 P.F. lag |
| | | | |
| **Noise Level** | Noise levels shall not exceed the following: | | |
| **Description** | **Sound Pressure, A-scale, A-weighted** | | |
| Engine generator noise at ≤ 25 dBA reduction | | | ft |
| Intake noise at | | | ft |
| Exhaust noise at | | | ft |
| Noise from exterior of enclosure at | | | ft |
| **Emissions** | Emissions shall not exceed the following: US EPA Tier 4 | | |
| **Description** | **ounces/hour (grams/hour) Detroit, MI data:** | | |
| Particulate | Later | | |
| Carbon monoxide (CO) | Later | | |
| Nitrogen oxides ($NO_x$) | Later | | |
| Unburned hydrocarbons (HC) | Later | | |
| Sulfur dioxides (SO2) | Later | | |
| **Electrical Characteristics** | | | |
| The diesel generator shall be capable of accepting load within the specified number of seconds after start command is initiated: | | <10 seconds | |
| The following parameters shall be guaranteed during the specified loading sequence below: | | **Minimum** | **Maximum** |
| Voltage variation, percent of rated generator terminal voltage | | 70 | 110 |
| Frequency variation, percent of rated frequency | | 2 | 2 |
| Loading sequence (Time starts when diesel generator is ready to accept load and it is connected to the electrical system.): | | | |

| **Starting Order** | **Running Load (later)** | | **Starting Load (later)** | |
|---|---|---|---|---|
| **Period/Time (later)** | **kW/Power Factor** | **Percent Motor Load** | **kW/kvar** | **Load Type** |
| (ATS 1) Fire pump EB | | | | <Select/enter..> |
| (ATS 2) 480V / 277V 3Ø Main distribution board | | | | <Select/enter..> |
| (ATS 1) 480V / 208V / 120V other distribution board | | | | <Select/enter..> |
| | | | | <Select/enter..> |
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# 1000 KW Diesel Generator Specification Sheet

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## Diesel Engine and Fuel Supply

| **Diesel Generator Set Name** | **Number of Units** | **ID Number** |
|---|---|---|
| W.S.U. Engineering Building | One (1) | |
| Fuel Type WSU:Clean fuel specs | No. 2 fuel | |
| Dual fuel types | N/A | |
| Rated engine speed, maximum | 1,800 rpm | |
| Stroke cycle | Manufacturer's standard | |
| Location | Outdoor Indoor | |
| Enclosure type | Outdoor,NEMA 3/12 | |
| Standard for manufacturing and testing | Either ANSI/IEEE/NEMA/NFPA | |
| Generator terminal nominal voltage | 480 V/277 V VAC (in accordance with NEMA MG1) | |
| Nominal power system frequency | 60 Hz | |
| Site altitude 650ft (183M) | Less than | |
| Design ambient temperature range, °F (°C) | | |
| Lube oil makeup tank required | As required by manufacturer lube oil circulation pump with constant temperature monitor alarm | |
| Exterior paint color | Manufacturer's standard later | |
| Starting method | Manufacturer's standard DCV batteries; wet cell | |
| Number of stored energy starts | Five starts with 30 seconds of cranking for each start | |
| Exhaust silencer mounting location WSU data | Outside and remote from engine generator unit later | |
| Air cleaner Type 2≤ 25dBA | Dry type with precleaner | |
| Air cleaner location on machine | Outside and remote from engine generator unit later | |
| PIT/enclosure air exfiltration<br>Cooling method monitored & alarms | Purchaser-furnished cooling tower with Supplier-furnished shell an tube type single-pass heat exchanger later | |
| Description | Minimum 10 percent design margin shall be added to the heat exchanger size | |
| Coolant considerations | Select fan belts or<br>Select electric fans later | |
| Day tank size, hours of operation at rated load | 100 hrs | hours of operation hrs |
| Day tank construction | Double-wall construction with instrumentation/alarms | |
| Day tank location | Remote mounted | |
| Additional Requirements<br>Diesel GenSet Fuel<br>Belly Tank | * Provide fill nozzle drip control entry/vent piping, sampling provision, fuel level monitoring displays; high alarm, high-high interlock with overfill protection & beacon; low alarm, low-low interlock.<br>* Monitored fuels usage data to MFR's control panel.<br>* Duel fuel oil filter set (replaceable filters; one on-line).<br>* Low point drain (condensate water drawoff).<br>* F.O. pump circulator with pressure control valving (monitored and alarms); with maintained fuel temperature | |

# 1000 KW Diesel Generator Specification Sheet

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| | | | | |
|---|---|---|---|---|
| **Generator** | | | | |
| Operating voltage range, percent of generator rated voltage | | | 5 percent to -5 percent | |
| Steady-state voltage regulation, percent of generator rated | | | 1 percent to -1 percent | |
| Excitation type | | Brushless - permanent magnet pilot exciter | | |
| Temperature detector | | Two stator RTDs per winding and one bearing RTD for each sleeve bearinc | | |
| Protection class | | IP22, open dripproof guarded | | |
| Insulation class | | Manufacturer's standard "H" | "F" optional | |
| Winding pitch | | Two-thirds (67 percent) | | |
| **Current Transformers** | | | | |
| **Location** | **Ratio** | **Accuracy Class** | **Quantity per Phase** | **Total Quantity** |
| Generator neutral side of each phase | | C400 | ØA 2<br>ØB 2<br>ØC 2 | later |
| Generator line side of each phase | | C400 | ØA 3<br>ØB 3<br>ØC 3 | later |
| Generator breaker | | C400 | | later |
| Generator neutra | | C200 | | later |
| **Additional Requirements**<br>**Solid state monitoring display, control, interlocks, alarms TCP/IP, DH +** | | | | |
| **Neutral Grounding Equipment** | | | | later |
| | | | | **Maximum ground current (amperes)** |
| Method of neutral grounding | | High resistance grounding | | |
| | | | | later |
| **Grounding Device** | **Type** | | | |
| Resistor<br>Eaton, Square D | Heavy-duty outdoor stainless steel strip type with aluminum enclosure. Electrical terminals shall be insulated bushings. lat | | | |
| | **Ratings** | | **Value** | **Unit** |
| | Rated voltage | | | |
| | Rated ohms | | | |
| | Current rating | | | |
| | Duration | | | |
| | Quantity | | | |
| | Quantity | | | |
| Disconnect Switch<br>Eaton, Square D | | | | later |
| | | **Ratings** | **Value** | **Unit** |
| | | Rated voltage | | later |
| | | Current rating | | later |
| | | Quantity | | later |
| | | | | |
| | | | | |
| | | | | |

# 1000 KW Diesel Generator Specification Sheet

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## Outdoor Enclosure Requirements

| **Design Criteria Detroit City Data BOCA Basis** | **Requirement** | **Unit** |
|---|---|---|
| Wind loading shall be based on a wind velocity of | | miles/hr |
| Snow loading shall be based on a loading of | | pounds/square foot |
| Enclosure color shall be | | |
| Sound attenuation enclosure required (Yes/No) | Yes Level 2 | |
| | | |
| | | |

The following shall be included in/with the enclosure/unit housing:

| | |
|---|---|
| Interior heating | Yes |
| Interior lighting | Yes |
| Ventilation Fans(s) & motor protection | Yes |
| Subbase fuel tank ~1,100 Gallon | Yes |
| Heavy-duty skiddable base of formed steel | Yes |
| Heavy-duty skiddable base with fuel tank | Yes |
| Exhaust silencing system housed within the enclosure | later |
| Intake filter housed within the enclosure | later |
| All starting and ancillary equipment housed within the enclosure | Yes |
| Convenience GFCI outlets six each | Yes |
| | |
| Additional Requirements | |

## Instrumentation Requirements

| **Equipment** | **Type** | **For:** |
|---|---|---|
| Fuel Tank HL/HHL alarm<br>LL/LLL alarm | Level switches | HHHL/ LLLL interlock + beacon |
| | Transmitters | Level/flow/ flow totalizer |
| | Level Indicators | One; illuminated |
| Cooling Water Temperature TSN/TSHH | Level switches | HHHL/ LLLL interlock + beacon |
| | Transmitters | Day tank level & temperature |
| | Level Indicators | One; illuminated |
| Manufacturer's standard later<br>Fuel oil delivery/handling control features | Level switches | Vibration |
| | Transmitters | Flow consumption rate/total |
| | Level Indicators | Pressure; temp: RTD, T/C |

## Electrical Connections

The generator terminal and electrical auxiliary power connection are described as follows:

| **Item** | **Description** | **Entrance** |
|---|---|---|
| Generator line side terminals | | Bottom |
| Generator neutral side terminals | | Bottom |
| Generator breaker, generator side connections | | Top |
| Generator breaker, load side connections | | Top |
| Generator control panel | | Side |
| Neutral; earth ground | | |

## Electrical Power Sources by Purchaser

| **Description** | **Code** | **Voltage** |
|---|---|---|
| Annunciator power | LV-3 Low voltage (power) | 120 VAC |
| DC charger power | LV-3 Low voltage (power) | 480 VAC |
| Control panel power | LV-3 Low voltage (power) | 120 VAC |
| Auxiliaries | CP-2 Control power | 125 VDC |
| Fractional HP pumps/fans | | 120 VAC |

| | |
|---|---|
| Additional Requirements | The manufacturer shall state all digital signal circuit features monitor displays, operator interface pages, trend data displays data capture and retention, alarm status displays, sequence of events (with time stamp), control panel usage. Describe external analog/digit signal connectivity to Owner's remote control room. Include diesel engine and electric generation status data; include production rate/totalization data. Describe GenSet control display features (A-B PanelVIsion). |

## 1000 KW Diesel Generator Specification Sheet

**(Page 6 of 7)**

| **Control Automatic Transfer Switch Command Signal** | | | |
|---|---|---|---|
| Diesel generator will be controlled from (later) | Local and Remote (PLC or DCS furnished by Purchaser) | | |
| The electrical equipment to be mounted on or within the local control cabinet shall include, but not be limited to, the following: | | | |
| **Description** | | **Quantity** | **Unit** |
| "Stop" and "Start" engine control switches with indicating lights | | | Lot |
| Red mushroom "Emergency Stop" push button | | | Each |
| Three-position (Off-Local Manual-Remote Auto/Manual) selector switch maintained in each position with overlapping contacts from Local Manual to Remote Auto/Manual, indicating light | | | Each |
| Speed control switch (decrease-increase) | | | Each |
| Voltage control switch (decrease-increase) | | | Each |
| Set of generating unit accessories including meters, switches, and lights as required to properly operate the complete generating unit as recommended by the Supplier Reveal all these components and circuit configurations | | | Lot |
| Annunciator, ISA Sequence A Capture sequence of shutdown events | | | Each |
| Lot of fuses and terminal blocks | | | Lot |
| Protective relays as described in "Electrical Equipment and Design" package Provide that package | | | Lot |
| Voltage regulator Whose? Provide data/descriptions | | | Each |
| Governor Whose? Provide data/descriptions | | | Each |
| Synchronizing equipment Whose? Provide data/descriptions | | | Lot |
| Potential transformers Whose? | | | Each |
| Current transformers Whose? | | | Each |
| Terminal blocks to terminate all external connections Whose? Test Switches? | | | Lot |
| Terminal blocks for MV interconnections | | | Lot |
| Excitation package Whose? Provide data/descriptions | | | |
| Electrical connector crimp-lug whose? Terminal markings: describe | | | |
| **Description** | **Voltage** | **Quantity** | **Unit** |
| Terminal blocks for one 3-phase ac power source | | Later | Lot |
| Terminal blocks for one single-phase ac power source | | Later | Lot |
| Terminal blocks for one dc power source | | Later | Lot |
| | | | |
| The following is a minimum listing of analog input signals from the local control panel to the DCS that are required to be furnished by the Supplier | | | |
| Generator volts Each phase | | | |
| Generator amperes Each phase | | | |
| Generator kVAR | | | |
| Generator frequency | | | |
| Generator kW | | | |
| Generator Power Factor | | | |
| Speed | | | |
| Generator stator winding temperature (RTD) (one per phase) | | | |
| Generator inboard bearing temperature (sleeve bearing only) | | | |
| Generator outboard bearing temperature (sleeve bearing only) | | | |
| Synchronous operation status. | | | |
| | | | |

# 1000 KW Diesel Generator Specification Sheet

(Page 7 of 7)

| | |
|---|---|
| **Control (continued)** | |
| The following is a minimum listing of digital output signals from the local control panel to the Owner's Building Automation system that are required to be furnished by the Supplier: Digial RS:485 TCP/LP (or other) signals are acceptable | |
| Local-Remote selector switch in "Local Manual" | |
| Local-Remote selector switch in "Remote Auto/Manual" | |
| Local-Remote selector switch in "Off" | |
| Generator diesel engine "Running" | |
| Generator diesel engine "Not Running" | |
| Generator diesel engine "Overspeed Alarm" | |
| Voltage control at upper limit | |
| Voltage control at lower limit | |
| Speed control at upper limit | |
| Speed control at lower limit | |
| Local emergency stop push button actuated | |
| Speed regulation in isochronous mode | |
| Speed regulation in load sharing isochronous mode | |
| Speed regulation in droop mode | |
| Alarm outputs for each condition tripping the lockout relay(s) | |
| Generator "Overvoltage Alarm" | |
| Generator "Low Voltage Alarm" | |
| Generator "Ready to Load" (at rated speed and voltage) | |
| Generator "At Maximum Rated Load" | |
| Generator fail to start alarm | |
| Generator annunciator "Common Trouble Alarm" | |
| Generator annunciator loss of dc power alarm | |
| Generator normal shutdown in progress | |
| Generator normal shutdown sequence time elapsed | |
| Generator lockout relay reset | |
| Generator lockout relay tripped | |
| Generator synchronization package outputs | |
| Generator Auto-Start disabled | |
| Generator emergency shutdown initiated | |
| | |
| | |
| The following is a minimum listing of digital local control panel input signals from the Owner's B.A.S. to the local control panel that may be required to be furnished by the Supplier: | |
| Generator start command (momentary contact) | |
| Generator stop command (normal shutdown) (momentary contact) | |
| Generator voltage increase (momentary contact) | |
| Generator voltage decrease (momentary contact) | |
| Generator speed increase (momentary contact) | |
| Generator speed decrease (momentary contact) | |
| Generator droop mode select (maintained contact) | |
| Generator isochronous mode select (maintained contact) | |
| Generator load sharing isochronous mode select (maintained contact) | |
| | |
| | |
| Enclosure protection | NEMA 1, gasketed |
| Additional Requirements | |

# SECTION 263213 – 2000 KW DIESEL ENGINE GENERATOR

## PART ONE - GENERAL

### 1.1. SCOPE OF SUPPLY

Scope of supply shall include furnishing the diesel generator as specified herein and on the Diesel Generator Specification Sheets included at the end of this section.

### 1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply include the following:

(Later)

### 1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the diesel generator are indicated on the Diesel Generator Specification Sheets included at the end of this section.

### 1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

| Work | In Accordance With |
|---|---|
| Design and fabrication of the engine generator set | SAE, NFPA, NEMA, IEC 34, AGMA, MIL Std 705C, US EPA Tier 4 |
| Design and construction of pressure boundary piping & vessels | ASME Code for Power Piping, B & PV sections: I, VIII, IX. ANSI/ASME B31.1 - Power Piping |
| Design and construction of flanges | ANSI B16.5 |
| Design and construction of small bore connections 2 inches (50 mm) and less | ANSI B16.11 |
| Design and construction of radiator and fan | HEI - Heat Exchange Institute, TEMA - Standard of Tubular Exchanger Manufacturers Association, Class C |

| Work | In Accordance With |
|---|---|
| Fuel oil storage tank | NFPA, UL, API |
| Design and construction of electrical components | NEMA, IEEE |

## 1.5 MATERIALS

The following materials shall be used:

| Component | Material |
|---|---|
| | |

## 1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

| Component | Manufacturer |
|---|---|
| Diesel engine generator set | Caterpillar, Kohler, Onan, Generac, Cummins |
| Radiators | Smithco Engineering, Americool, O&M Manufacturing, ABB, or Coiltech |
| Governor | Woodward Model 2301A, Woodward 701A, Woodward Model 723, or equal |

## 1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This Quality Assurance Program Planner testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

| Tests | In Accordance With | Conducted By |
|---|---|---|
| Purchaser | ASME Code for Power Piping, ANSI/ASME B31.1 - Power Piping | Supplier |
| Shop performance tests | ISO and manufacturer's standard QA Test Plans and as specified herein | Supplier |
| Field performance tests | After field installation, the Purchaser will test the completely assembled equipment for compliance with all performance requirements specified herein. Testing shall be done in accordance with the applicable ISO standards. | Purchaser |

### 1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

| Document Number/Description | Title | Revision |
|---|---|---|
| None Identified | | |

## 2 PART TWO - PRODUCTS

### 2.1 GENERAL

This article covers the design, performance, and construction requirements for all diesel generator units in which the diesel engine and generator are installed on a common steel base.

The following definitions define the duty type specified on the Diesel Generator Specification Sheets included at the end of this section. Load factor shall be defined as the sum of the products of "percent of time x percent of load." "Percent of time" is defined as "time at specific load/total operating time" and "percent of load" is defined as "specific load/rated load." Extended idling time and the time when the generator set is not operating do not enter into the calculation for load factor:

Continuous Duty. Rated kW and kvar output available without varying load for an unlimited time. The unit shall be suitable for a 100 percent load factor.

Prime Duty. Rated kW and kvar output available with varying load for an unlimited time. The unit shall be suitable for a 70 percent load factor.

Standby Duty. Rated kW and kvar output available with varying load for the duration of the interruption of the normal source power. The unit shall be suitable for a 60 percent load factor.

The diesel generator unit shall meet the operating conditions and equipment sizing criteria as specified herein and on the Diesel Generator Specification Sheets.

## 2.2 PERFORMANCE

The diesel generator set shall be designed to operate reliably under the conditions specified on the Diesel Generator Specification Sheets.

The diesel generator set shall consist of a diesel engine directly coupled to a generator and shall have a unit control panel. The equipment shall be mounted on a common steel base and, housed in a required level 2 weatherproof acoustical enclosure designed to meet the requirements specified on the Diesel Generator Specification Sheets. The unit shall be furnished with all auxiliary equipment required to locally operate it. When feasible, all transformers, motor starters, and electrical control equipment required for operation of the unit as specified in this article shall be furnished and mounted within the confines of the steel base. All interconnecting piping and wiring for equipment mounted on the steel base shall be factory installed.

A two-hole bronze grounding pad attached to the generator frame shall be supplied adjacent to the main lead terminal housing.

A two-hole grounding pad shall be placed on each end of the diesel generator skid frame.

## 2.3 DESIGN CONDITIONS

The diesel generator shall be designed and constructed in accordance with the conditions specified herein.

The generator with associated drive, radiator, exhaust silencer, and accessory equipment will be located as specified on the Diesel Generator Specification Sheets.

### 2.3.1 Starting and Loading

The unit shall be capable of being started, synchronized to the system, and loaded to the full rating of the unit without dependence upon ac auxiliary power for a minimum of 5 minutes. The unit shall be capable of accepting load in accordance with the specified loading sequence shown on the Diesel Generator Specification Sheets. The voltage and frequency variations shall remain within the tolerances specified on the Diesel Generator Specification Sheets.

### 2.3.2 Fuel Storage and Supply System

A complete fuel supply system including a fuel oil sub-base belly mounted storage tank, fuel oil transfer pumps, all valves and piping, and all fuel control level and flow metering and sensor devices shall be furnished. The day tank shall be sized to operate the diesel generator at full load for the time specified on the Diesel Generator Specification Sheets. If an external storage tank is required due to capacity needs, that fuel tank shall be located remote from the generator set.

The day tank shall be equipped with a gauge glass to show fuel level inside the tank and the required instrumentation shall be in accordance with the Diesel Generator Specification Sheets. Fuel filling operations shall not disturb the accuracy of the level indication system.

The day tank shall be provided with the following minimum connections:

One full sized fuel oil supply.

One full sized fuel oil return.

Vent.

Fill. (with local spill capture feature)

Drain.

Two connections for illuminated level gauge glass.

Level sensor monitor/alarm, & percent filled features

### 2.3.3 Control and Operation Requirements

The unit shall be controlled as specified on the Diesel Generator Specification Sheets. Unit performance and alarm management external communication digital messaging, and limited command/control features shall be provided.

## 2.4 DIESEL ENGINE CONSTRUCTION

A turbocharged diesel engine with an aftercooler, designed for operation for the fuel and ambient conditions specified on the Diesel Generator Specification Sheets, shall be provided. The engine shall be sized to provide the minimum required net generator output kVA at the rpm and at power factor specified on the Diesel Generator Specification Sheets. The engine shall be furnished with all accessories required for a complete unit and shall be the manufacturer's standard for this service.

### 2.4.1 Engine Cooling System

The coolant water radiator type shall be as specified on the Diesel Generator Specification Sheets. The engine cooling system shall be filled with a permanent antifreeze mixture with rust inhibitor. A jacket water electrical heater shall be furnished and sized to maintain jacket water at 100° F (38° C) with a winter ambient temperature as specified on the Diesel Generator Specification Sheets. The jacket water heater shall be thermostatically controlled and shall be monitored and alarmed.

The engine shall also be equipped with an engine mounted jacket water pump and thermostat to properly control engine temperature.

### 2.4.2 STARTING SYSTEM

For engines using an electric starting system, the starting system shall be complete with wet cell batteries, battery charger, battery rack, and cables. The battery shall be sized to provide the specified number of starts and cranking time at firing speed at any ambient between the specified minimum and maximum design ambient temperatures. An electrical heat pad for the battery shall be provided to keep the battery in a ready state at the specified minimum ambient temperature. All parameters are provided on the Diesel Generator Specification Sheets. The charger shall be furnished with ground detection, charger trouble alarm, and an automatic equalize timer for fast recharge. The charger shall be suitable for operation at the Purchaser-provided input power conditions and shall alarm on loss of power. Recharge time for a fully discharged battery shall be as specified on the Diesel Generator Specification Sheets. For engine generator sets rated 750 kW and above, a redundant electric starting motor shall be provided.

For engines using an air starting system, an air starting system shall be furnished complete with air starting motors or direct compressed air injection into the cylinders, compressed air storage tank, ac electric motor driven air compressor, air-cooled engine driven air compressor, air filters, air dryers (as required), and all control, alarm, and instrumentation devices/components. (Not Chosen)

The air starting system shall be sized to provide the specified number of starts and cranking time at firing speed at all ambient conditions between the specified minimum and maximum design ambient temperatures without air compressor operation being required. The electric motor driven air compressor shall provide the normal source of air to recharge the compressed air storage tank. The air-cooled engine driven air compressor will serve as a backup when no electric ac power is available. Each air compressor shall be capable of recharging the air storage tank in 30 minutes. (Not Chosen)

The air-cooled engine air compressor shall be provided with an electric direct current motor starting system. The batteries shall be capable of maintaining the cranking speed recommended by the engine manufacturer through a 6 minute cycle (15 seconds cranking, 15 seconds rest, 12 consecutive cycles). The batteries shall be mounted in a storage rack. An automatic battery charger of the self-regulating type with alarm contacts for loss of power and trouble shall be furnished. The batteries and battery charger shall be mounted on the same base as the engine and air compressor. (Not Chosen)

### 2.4.3 Combustion Air Intake.

The combustion air intake with filtration and noise suppression shall be in accordance with the Diesel Generator Specification Sheets.

### 2.4.4 Fuel System

A fuel management system shall be furnished to regulate fuel flow to maintain constant rated speed regardless of load variations.

The monitored and alarmed fuel system shall include an engine governor, fuel metering equipment, actuator, twin isolable strainers, engine driven fuel pump, relief valve, filters, and fuel cutoff valves. A day tank shall be provided as specified herein under the article titled Fuel Storage and Supply System.

An electric dc motor driven startup fuel priming pump shall be provided if required by the manufacturer's design for "black start" of the diesel generator set.

### 2.4.5 Lubrication System

The monitored and alarmed lubrication system shall provide positive lubrication for the high-speed bearings and main gears, and pressure jets for secondary gears. The remaining bearings and gears may be splash lubricated.

Equipment for the system shall include an engine driven main oil pump, system pressure regulator, engine block heater, full flow oil filter set, heat exchanger, pressure and temperature sensing devices, indicators, and monitoring circuits.

The lube oil dual path tubular heat exchanger shall be designed to use the engine coolant as the cooling medium. The heat exchanger shall be mounted on the unit base.

An electric dc motor driven prelube oil pump shall be provided if required by the manufacturer's design for "black start" of the diesel generator set.

Whenever ~~a~~ an atmospheric pressure lube oil makeup tank is specified on the Diesel Generator Specification Sheets, the Supplier shall provide a 30 gallon (113 liter) (minimum size) lube oil makeup tank (with stand, if necessary) suitable for gravity feed to the engine and complete with pipe and fittings, level sensors with alarms, a one-way check valve, and an oil level regulator.

Provisions shall be made to facilitate the removal of used engine oil from the unit for discharge into drums.

If required by the manufacturer's design, The Supplier shall furnish thermostatically controlled and alarmed lube oil heater(s) and lube oil circulation pump(s) to keep the diesel engine in a ready state during cold weather, based on the minimum specified design ambients.

### 2.4.6 Exhaust System

The exhaust system shall consist of an exhaust silencer, expansion joints, Interconnecting ductwork, and the necessary amount of exhaust pipe to allow the unit to be exhausted outdoors. The silencer shall be designed to limit the noise to the levels specified on the Diesel Generator Specification Sheets.

2.4.7 Unit Controls

Unless specified otherwise herein, the Diesel Generator synchronous speed governor shall use electronic digital logic and shall be Woodward Model 2301A, Woodward Model 701A, Woodward Model 723, 501A or equal. Loading and synchronizing of the diesel generator shall be with a Woodward Digital Synchronizer and Load Control (DSLC) module or equal. External devices and software interface required for setting and programming the governor or load control shall be furnished by the Supplier. The Supplier shall provide the engineering, software, and settings. The Supplier shall submit the calculations for review by the Purchaser.

The control system features shall include the following:

Load sharing, if specified on the Diesel Generator Specification Sheets. The equipment shall be capable of isochronous load sharing with other parallel generators:

Automatic generator loading and unloading shall support bumpless load transfer.

Automatic Transfer Switch communication and coordination capability: Any transfer switch that detects Utility power failure or degraded Utility bad power will command signal the new 2000 KW GenSet to start and then deploy emergency power to each/all paralleled ATS switches. Refer to electrical Drawing E-105.2 that identifies the ATS assignment numbers and destinations served by the 2000 KW GenSet. That ATS connection to the deployed emergency GenSet will be retained until the ATS power condition monitoring circuits determine that utility incoming power has been reliably restored within allowable limit(s) setpoint condition. After power restoration parameters are satisfied, and then initiate a closed transition sequence to reconnect loads to utility power resources. No parallel external electrical connected GenSet operation design is contemplated.

Each of several ATS units with their sensor circuits and their time sequencing circuits will be equipped with a control output signal, any one signal (or all simultaneously) paralleled signals will command start the 2000 KW GenSet.

Design and deploy a Sequence of Event (SOE) time history circuit feature that monitors all/any ATS command events (or for all/any scheduled maintenance calls) for GenSet starts to resolve realtime start event conditions in ~one millisecond intervals. Retain all SOE records for ~ one year.

The existing Engineering Building independently sited 500 kW GenSet with its Y. 2014 configured connections and start command switch characteristics to the Utility power and to select building loads the will be retained intact. No parallel external electrical connected GenSet operation design is contemplated. The 500 kW GenSet therefore retains its three assigned ATS switched connected loads.

The automatic synchronizing scheme for the new 2000 KW GenSet shall be designed to select and synchronize the diesel generator across each of two 480V 3Ø 60Hz circuit breakers: 1) One 1200 AF (1200AT) 2) One generator mounted (2400AF). Furnished with the new equipment identified on the Diesel Generator Specification Sheets:

Automatic Transfer Switch(es) initiate start up.

Dead bus closing system.

VAR/power factor control, if specified herein.

Engine speed control.

Isochronous or droop mode.

Actuator as required by the application.

Load bank test alignment capability, if specified herein.

The control system shall be designed for black start of the 2000 KWdiesel generator. It shall be assumed that utility restoration ac power will not be available until approximately 5 minutes after the engine GenSet has been deployed.

All motors starters, cabling, and contactors for protected electric equipment provided by the Supplier shall be furnished terminated and tested.

### 2.4.8 Diesel Generator Unit Local Control Panel

Electrical control and metering equipment for the diesel generator shall be furnished, mounted, and wired on the unit control panel. If mounted on the diesel generator steel base, the local unit control panel shall be mounted with resilient mounts. The local unit control panel shall be completely enclosed at the front, rear, top, and both sides. A hinged front panel shall be provided to allow for maintenance of the controls and instruments. Equipment furnished shall be in accordance with the

Diesel Generator Specification Sheets. Analog monitoring and digital alarm circuits for the buyer’s external field circuits shall be brought to terminal blocks or connections.

If specified or allowed on the Diesel Generator Specification Sheets, the Supplier may propose hardened industrial Panel View touchscreen operator interface panels to achieve the specified control and alarm functions for the local control panel. The interface monitoring and alarm panel shall provide operator access to all information, alarms, and controls for operation of the diesel generator and ancillary systems. It shall include, but not be limited to, voltages, currents, kW, kvar, engine parameters such as cylinder and exhaust temperatures, oil pressure, and temperature, coolant pressure, and temperature.

All operator interface command functions, except screen paging, shall be designed for two-step operation. The operator shall be required to make one touchscreen action to select the function to be performed and a touchscreen action to execute the function. Seller shall identify his standard serial data monitoring top/IP, models external monitoring and alarm capabilities. Seller shall identify features as a mandatory alternative offering.

2.4.9 Diesel Generator Unit Remote Control Interface

The requirements and equipment supply for remote control of the diesel generator unit are specified on the Diesel Generator Specification Sheets.

2.5 Generator Construction

The unit shall be in accordance with the applicable standards specified in Article 26 3213 1.4, and shall include a synchronous wye connected generator designed for direct connection to the engine previously specified. Generator construction shall include damper windings and shall conform to the applicable standards for synchronous generators, salient-pole type. The generator and exciter shall be provided with an open dripproof, fully guarded, screen protected enclosure. The minimum rated capacity shall be at least equal to or greater than the maximum engine overload capacity and at rated power factor load. The Supplier shall guarantee satisfactory operation at maximum capacity continuously and at all other levels of reduced loading. The Supplier shall design and furnish any required equipment, monitoring and protective interlock devices, or materials to ensure that the generator provides voltage, current, and frequency within the allowable tolerances of all connected loads being supplied.

The insulation system of the armature and field windings may be or Class H [356° F (180° C) hot spot] or Class F [311° F (155° C) hot spot]. Based upon a 104° F (40° C) ambient temperature and a 50° F (10°C) low.

(10° C) hot spot allowance, the temperature rises when measured by resistance shall not exceed the following:

| Duty Basis | Class F [311° F (155° C) hot spot] | Class H [356° F (180° C) hot spot] |
|---|---|---|
| Standby | 266° F (130° C) | 302° F (150° C) |
| Prime | 221° F (105° C) | 257° F (125° C) |
| Continuous | 176° F (80° C) | 221° F (105° C) |

A vacuum pressure impregnation (VPI) process shall be utilized on form wound stator windings.

The manufacturer shall provide a stator coil pitch, coil distribution, and skew to minimize the total harmonic distortion (THD) to less than 5 percent.

The armature and field windings shall be coated with a fungus resistant resin.

The generator shall be provided with the specified exciter in accordance with the Diesel Generator Specification Sheets. It shall enable the generator to sustain 300 percent of rated full load current for 10 seconds during a fault condition.

An automatic voltage regulator with 3-phase sensing shall be provided. The regulator shall have overexcitation protection. A static voltage adjuster shall be provided for use with an automatic synchronizer.

All external control and auxiliary power wiring connections shall be made at terminal blocks at one location on the unit.

The generator neutral shall be closed. Space heaters shall be furnished inside the generator enclosure. Space heater capacity shall be as required to maintain the internal temperature within the generator enclosure above the dew point when the generator is idle. Space heaters shall be rated for the appropriate conditions. The space heater rated voltage shall not be less than 1.5 times the applied voltage. The Supplier shall provide all internal space heater wiring and branch circuit protection. A complete space heater control thermostat and temperature alarm sensor system shall be furnished by the Supplier as an integral part of the diesel generator unit. The space heater control system shall include an interlock with the diesel generator unit so that the heaters are de-energized when the generator is operating. An adjustable thermostat shall also control the space heater.

## 2.6 Electrical Equipment Construction

Except as otherwise specified, all necessary electrical equipment and wiring associated with the unit shall be provided and factory installed on the unit and shall be included in accordance with manufacturer’s NEC-70 compliant standard practices.

### 2.6.1 Unit Base Junction Box

A single diesel generator unit base junction box complete with antecedent low voltage motor control center circuit wiring to all manufacturer's motors heaters lighting and terminal blocks shall be furnished at one location for all equipment located on the diesel generator base. Terminal blocks shall be provided for all motor power circuits, space heater circuits, monitoring and control circuits, current transformers, and potential transformers. The generator output terminals may be housed in a separate box. The generator output terminals shall be separated from the other circuits in the terminal box by a metal barrier if they are in the same box as the balance of terminations.

All wiring and raceway required between devices mounted within or on the diesel generator unit base shall be factory installed.

### 2.6.2 Neutral Grounding Equipment

The generator shall be furnished with the specified neutral grounding equipment listed on the Diesel Generator Specification Sheets.

### 2.6.3 Motors

All motors furnished under this specification for the diesel generator shall be in accordance with the requirements of the seller's standard Low Voltage Induction Motors specification or the Single-Phase Motors specification.

Motors located within the confines of the unit steel base shall be grounded in the motor terminal housing.

### 2.6.4 Nameplates

Engraved nameplates shall be furnished for the front of each unit. The Purchaser will provide nameplate inscriptions during detailed design.

### 2.6.5 Wiring and Wiring Diagrams

The Supplier shall provide internal cabinet wiring, connections, and diagrams in accordance with the requirements of the following articles:

Cabinet Wiring. All wiring used within the cabinet connected to external GenSet sensors, switches, alarms, powered equipment and to the owner's remote control external locations shall be installed and tested at the factory.

All wiring shall be neatly and carefully installed in wiring gutters or raceways. All power supply circuits shall be provided with suitable isolation/electrical protection means consisting of either fuses or circuit breakers.

A continuous bare copper ground bus, with a compression or clamp type connector at one end, shall be provided in each cabinet. All cabinet equipment requiring grounding shall be connected to this ground bus.

Diagrams. The Supplier shall furnish schematic, connection, interconnection, one-line, and three-line diagrams. The drawings shall be in accordance with the exchange of engineering information agreed to during detailed design conferences.

The instrumentation and control sensor switches, display components, transmitters/transducers and controlled equipment shall be documented in a Process and Instrument Diagram with its corresponding instrument index (tags, process description, PLC identity, circuit NOS, set point data, et.a1.

### 2.6.6 Instruments and Devices

Equipment furnished shall be in accordance with the Diesel Generator Specification Sheets.

## 2.7 Bus Duct

Where bus duct is specified on the Diesel Generator Specification Sheets for power conductors, the Supplier shall coordinate with the bus duct vendor to ensure that all materials required to complete the interface are provided by the bus duct vendor.

## 2.8 Enclosures

If specified on the Diesel Generator Specification Sheets, an enclosure for the diesel generator set shall be furnished in accordance with the design conditions, environment, and sound attenuation specified. When possible, a pitched roof shall be provided to prevent the accumulation of moisture and debris. Paint characteristics shall be in accordance with the Diesel Generator Specification Sheets.

All the doors on the enclosure shall be located in areas to allow ease of maintenance on the diesel generator set and allow access to and visibility of instruments, controls, engine, gauges, etc. Doors shall be lockable, gasketed, and shall be mounted with corrosion-resistant hardware. Doors to nonwalk-in enclosures shall be easily removable and mounted on lift-off hinges.

## 2.9 Tests

The diesel generator unit shall be tested in accordance with the requirements stated herein and the applicable standards.

### 2.9.1 Factory Test

All factory and site acceptance test plan steps, results objectives, and completion data shall be captured within the manufacturer's Quality Assurance Program submittal documentation.

The drive and generator shall be completely factory assembled and tested by the manufacturer to prove that they are assembled correctly, and shall be capable of meeting the net generator output kVA rating. All other components and support systems shall be thoroughly inspected by the Supplier prior to shipment. All control systems shall be tested to verify correctness of assembly and operation, applicable high potential tests, and applicable standard tests. The integrity and proper connection of all electrical circuits shall be verified/ and demonstrated.

The Owner shall be notified concerning test cycle Quality Assurance Plan activities 10 days in advance of test dates. Provide a timely invitation to witness tests.

### 2.9.2 On-Site Testing

Furnish a continuous on site four (4) hour 100% full load "Load Bank" test. Test to be conducted during normal business hours. 0830-1700 hours, Monday through Friday. WSU to be provided seven (7) day notice. WSU shall witness test.

### 2.9.3 Type Tests and Certificates

Where type tests and certificates are specified in Article 26 3213 1.7, Supplier shall perform the type tests as required and in accordance with all the applicable standards.

## 3 PART THREE - EXECUTION

Not Applicable.

END OF SECTION 263213

## 16032 Diesel Generator

### Instructions for filling out Diesel Generator Specification Sheet

Fill out cells in each worksheet as directed by the text and the project requirements. When finished making selections, print each page using the default page setup, select all sheets together, and print as a group, or print using the report manager.
Use the "Additional Requirements" section to fill in details or needs not covered by the tables. Create additional worksheets for each application type.

The "Selections" tab at the end of the workbook is for internal use only and cannot be modified.

Header and footer information should be edited for the specific project and specification.

| | |
|---|---|
| <Select/enter..> | Blue cells which are blank or contain the text <Select/enter...> contain menus for filling in the cell. |
| 🟨 | Blank yellow cells are to be filled out as dictated by the specific project requirements. |
| 120 VAC | Blue cells which contain specific text show the default or preferred selection, but also contain menus for filling in the cell. |
| Text | Yellow cells which contain specific text show the default or preferred selection, but can also be filled in by the specifier as dictated by the project requirements. As text is entered, use the "ALT-Enter" key combination as a carriage return to insert more than one row of text in a cell. |

## 2000 KW Diesel Generator Specification Sheets
(Page 1 of 7)

| | |
|---|---|
| **Interface Points and Scope of Work** | |
| The equipment and materials to be furnished shall include, but not necessarily be limited to, the following major items: | |
| Diesel generator and ancillary equipment | Yes |
| Exhaust silencer and piping between the silencer and the engine | Yes |
| Intake air filter and associated piping between the filter and the engine | Yes |
| Two Generator breakers: One 1200 at (1200AT); and one 2400AF (2400AT) | Yes |
| Bus between generator breaker and the generator | Yes |
| Fuel storage belly tank 1,100 GAL storage | Yes |
| Radiator | Yes |
| Battery for cranking and controls with accessory charger & battery stands | Yes |
| Protective relaying and alarms; control HMI display panel(s) | Yes |
| Compressed air starting equipment | Yes |
| Weatherprooof enclosure | Yes |
| Vibration isolators | Yes |
| Motor controls and starters | Yes |
| | |
| | |
| | |
| | |
| Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Supplier in accordance with the following: | |
| All necessary connections for the Purchaser's piping and instruments | Yes |
| All necessary instrument, power, and control wiring and raceways integral to any equipment furnished under these specifications, wire and term block identifications | Yes |
| All special tools or lifting lugs for offloading | Yes |
| All special tools required for erection of the equipment. Erection tools shall remain th property of the Supplier. All shipping costs to and from the jobsite shall be at the Supplier's expense. | Yes |
| Bolting materials between equipment furnished and the Purchaser's structural steel | Yes |
| Leveling blocks, soleplates, thrust blocks, matching blocks, and shims | Yes |
| All nuts, bolts, gaskets, special fasteners, backing rings, etc., between components and equipment furnished under these specifications | Yes |
| Hangers and accessories for piping furnished under these specifications | Yes |
| All piping and ductwork integral to or between any equipment furnished under these specifications, except as otherwise specified | Yes |
| A Quality Assurance Program test Plan & sign-offs; with MTR data | Yes |
| A complete operations and a maintenance manual with software | Yes |
| The following items of work will be furnished by the Purchaser: | |
| Miscellaneous piping and tubing between equipment | Yes |
| Permanent electric wiring to connect equipment terminal boxes to plant electrical system | Yes |
| Lubricants, coolants, and fuels for operation; air and oil filters | Yes |
| Solvents and cleaning materials | Yes |
| Grouting materials and the placing thereof | Yes |
| Operating personnel for startup and tests | Yes |
| | |
| | |

## 2000 KW Diesel Generator Specification Sheet(s)

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| | | | | |
|---|---|---|---|---|
| **Performance Guarantees** | | | | |
| **Diesel Generator Ratings**<br>**Emergency Power Duty 2000 KW** | | The diesel generator rating shall be the sum of the specified "minimum kW" load and diesel generator parasitic loads. | | |
| **Description** | | **Duty Type** | **Minimum KW** | **Power Factor** |
| Continuous load | | Standby duty | 2,000 | 0.8 lag |
| Manufacturer to state achievable load turndown ratio operations data | | | | 0.8 P.F. lag |
| | | | | |
| **Noise Level** | | Noise levels shall not exceed the following: | | |
| **Description** | | **Sound Pressure, A-scale, A-weighted** | | |
| Engine generator noise at ≤ 25 dBA reduction | | | | ft |
| Intake noise at | | | | ft |
| Exhaust noise at | | | | ft |
| Noise from exterior of enclosure at | | | | ft |
| **Emissions** | | Emissions shall not exceed the following: US EPA Tier 4 | | |
| **Description** | | **ounces/hour (grams/hour) Detroit, MI data:** | | |
| Particulate | | Later | | |
| Carbon monoxide (CO) | | Later | | |
| Nitrogen oxides ($NO_x$) | | Later | | |
| Unburned hydrocarbons (HC) | | Later | | |
| Sulfur dioxides (SO2) | | Later | | |
| **Electrical Characteristics** | | | | |
| The diesel generator shall be capable of accepting load within the specified number of seconds after start command is initiated: | | | 10 seconds | |
| The following parameters shall be guaranteed during the specified loading sequence below: | | | **Minimum** | **Maximum** |
| Voltage variation, percent of rated generator terminal voltage | | | 70 | 110 |
| Frequency variation, percent of rated frequency | | | 2 | 2 |
| Loading sequence (Time starts when diesel generator is ready to accept load and it is connected to the electrical system.): | | | | |
| **Starting Order** | **Running Load (later)** | | **Starting Load (later)** | |
| **Period/Time (later)** | **kW/Power Factor** | **Percent Motor Load** | **kW/kvar** | **Load Type** |
| (ATS 13) Fire pump | | | | <Select/enter..> |
| (ATS 16) Fan AC1 | | | | <Select/enter..> |
| (ATS 17) Fan AC2 | | | | <Select/enter..> |
| (ATS 18) Fan AC3 | | | | <Select/enter..> |
| (ATS 15) EMLP | | | | <Select/enter..> |
| (ATS 11) LP Lxx | | | | <Select/enter..> |
| (ATS 14) EDP | | | | <Select/enter..> |
| Gen EPI | | | | <Select/enter..> |
| (ATS 4) X former T1 EDC | | | | <Select/enter..> |
| UPS EP1 | | | | <Select/enter..> |
| (ATS 12) UPS (3355) | | | | <Select/enter..> |
| UPS EP2 | | | | <Select/enter..> |
| UPS Toshiba | | | | <Select/enter..> |
| Gen EP2 | | | | <Select/enter..> |
| (ATS 21) X former T2 | | | | <Select/enter..> |
| (ATS 20) rm 2354 A/C | | | | <Select/enter..> |
| (ATS 19) rm 2409 A/C | | | | <Select/enter..> |
| (ATS 5) rm 3505 clean | | | | <Select/enter..> |

# 2000 KW Diesel Generator Specification Sheet

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**Diesel Engine and Fuel Supply**

| **Diesel Generator Set Name** | **Number of Units** | **ID Number** |
|---|---|---|
| W.S.U. Engineering Building | One (1) | |
| Fuel Type WSU:Clean fuel specs | No. 2 fuel | |
| Dual fuel types | N/A | |
| Rated engine speed, maximum | 1,800 rpm | |
| Stroke cycle | Manufacturer's standard | |
| Location | Outdoor Indoor | |
| Enclosure type | Outdoor~~, walk-in~~ NEMA 3/12 | |
| Standard for manufacturing and testing | Either ANSI/IEEE/NEMA/~~ASE~~/NFPA/~~MIL or IEC~~ | |
| Generator terminal nominal voltage | 480 V/277 V VAC (in accordance with NEMA MG1) | |
| Nominal power system frequency | 60 Hz | |
| Site altitude 650ft (183M) | Less than ~~3,300 ft (1,000 m)~~ | |
| Design ambient temperature range, °F (°C) | | |
| Lube oil makeup tank required | As required by manufacturer lube oil circulation pump with constant temperature monitor alarm | |
| Exterior paint color | Manufacturer's standard | later |
| Starting method | Manufacturer's standard DCV batteries; wet cell | |
| Number of stored energy starts | Five starts with 30 seconds of cranking for each start | |
| Exhaust silencer mounting location WSU data | Outside and remote from engine generator unit | later |
| Air cleaner Type 2≤ 25dBA | Dry type with precleaner | |
| Air cleaner location on machine | Outside and remote from engine generator unit | later |
| PIT/enclosure air exfiltration<br>Cooling method monitored & alarms | Purchaser-furnished cooling tower with Supplier-furnished shell an tube type single-pass heat exchanger | later |
| Description | Minimum 10 percent design margin shall be added to the heat exchanger size | |
| Coolant considerations | Select fan belts or<br>Select electric fans | later |
| Day tank size, hours of operation at rated load | 100 hrs | hours of operation hrs |
| Day tank construction | Double-wall construction with instrumentation/alarms | |
| Day tank location | Remote mounted | |
| Additional Requirements<br>Diesel GenSet Fuel<br>Belly Tank | * Provide fill nozzle drip control entry/vent piping, sampling provision, fuel level monitoring displays; high alarm, high-high interlock with overfill protection & beacon; low alarm, low-low interlock.<br>* Monitored fuels usage data to MFR's control panel.<br>* Duel fuel oil filter set (replaceable filters; one on-line).<br>* Low point drain (condensate water drawoff).<br>* F.O. pump circulator with pressure control valving (monitored and alarms); with maintained fuel temperature | |

## 2000 KW Diesel Generator Specification Sheet

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| | | | | |
|---|---|---|---|---|
| **Generator** | | | | |
| Operating voltage range, percent of generator rated voltage | | | 5 percent to -5 percent | |
| Steady-state voltage regulation, percent of generator rated | | | 1 percent to -1 percent | |
| Excitation type | | Brushless - permanent magnet pilot exciter | | |
| Temperature detector | | Two stator RTDs per winding and one bearing RTD for each sleeve bearinc | | |
| Protection class | | IP22, open dripproof guarded | | |
| Insulation class | | Manufacturer's standard "H" | "F" optional | |
| Winding pitch | | Two-thirds (67 percent) | | |
| **Current Transformers** | | | | |
| **Location** | **Ratio** | **Accuracy Class** | **Quantity per Phase** | **Total Quantity** |
| Generator neutral side of each phase | | C400 | ØA 2<br>ØB 2<br>ØC 2 | later |
| Generator line side of each phase | | C400 | ØA 3<br>ØB 3<br>ØC 3 | later |
| Generator breaker | | C400 | | later |
| Generator neutra | | C200 | | later |
| **Additional Requirements**<br>**Solid state monitoring display, control, interlocks, alarms TCP/IP, DH+** | | | | |
| **Neutral Grounding Equipment** | | | | later |
| | | | | **Maximum ground current (amperes)** |
| Method of neutral grounding | | High resistance grounding | | |
| | | | | later |
| **Grounding Device** | **Type** | | | |
| Resistor<br>Eaton, Square D | Heavy-duty outdoor stainless steel strip type with aluminum enclosure. Electrical terminals shall be insulated bushings. lat | | | |
| | **Ratings** | | **Value** | **Unit** |
| | Rated voltage | | | |
| | Rated ohms | | | |
| | Current rating | | | |
| | Duration | | | |
| | Quantity | | | |
| | Quantity | | | |
| Disconnect Switch<br>Eaton, Square D | | | | later |
| | | **Ratings** | **Value** | **Unit** |
| | | Rated voltage | | later |
| | | Current rating | | later |
| | | Quantity | | later |
| | | | | |
| | | | | |
| | | | | |

## 2000 KW Diesel Generator Specification Sheet

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### Outdoor Enclosure Requirements

| **Design Criteria Detroit City Data BOCA Basis** | **Requirement** | **Unit** |
|---|---|---|
| Wind loading shall be based on a wind velocity of | | miles/hr |
| Snow loading shall be based on a loading of | | pounds/square foot |
| Enclosure color shall be | | |
| Sound attenuation enclosure required (Yes/No) | Yes Level 2 | |
| | | |
| | | |

The following shall be included in/with the enclosure/unit housing:

| | |
|---|---|
| Interior heating | Yes |
| Interior lighting | Yes |
| Ventilation Fans(s) & motor protection | Yes |
| Subbase fuel tank ~1,100 GAl | Yes |
| Heavy-duty skiddable base of formed steel | Yes |
| Heavy-duty skiddable base with fuel tank | Yes |
| Exhaust silencing system housed within the enclosure | later |
| Intake filter housed within the enclosure | later |
| All starting and ancillary equipment housed within the enclosure | Yes |
| Convenience GFCI outlets six each | Yes |
| | |
| Additional Requirements | |

### Instrumentation Requirements

| **Equipment** | **Type** | **For:** |
|---|---|---|
| Fuel Tank HL/HHL alarm<br>LL/LLL alarm | Level switches | HHHL/ LLLL interlock + beacon |
| | Transmitters | Level/flow/ flow totalizer |
| | Level Indicators | One; illuminated |
| Cooling Water Temperature TSN/TSHH | Level switches | HHHL/ LLLL interlock + beacon |
| | Transmitters | Day tank level & temperature |
| | Level Indicators | One; illuminated |
| Manufacturer's standard later<br>Fuel oil delivery/handling control features | Level switches | Vibration |
| | Transmitters | Flow consumption rate/total |
| | Level Indicators | Pressure; temp: RTD, T/C |

### Electrical Connections

The generator terminal and electrical auxiliary power connection are described as follows:

| **Item** | **Description** | **Entrance** |
|---|---|---|
| Generator line side terminals | | Bottom |
| Generator neutral side terminals | | Bottom |
| Generator breaker, generator side connections | | Top |
| Generator breaker, load side connections | | Top |
| Generator control panel | | Side |
| Neutral; earth ground | | |

### Electrical Power Sources by Purchaser

| **Description** | **Code** | **Voltage** |
|---|---|---|
| Annunciator power | LV-3 Low voltage (power) | 120 VAC |
| DC charger power | LV-3 Low voltage (power) | 480 VAC |
| Control panel power | LV-3 Low voltage (power) | 120 VAC |
| Auxiliaries | CP-2 Control power | 125 VDC |
| Fractional HP pumps/fans | | 120 VAC |

| | |
|---|---|
| Additional Requirements | The manufacturer shall state all digital signal circuit features monitor displays, operator interface pages, trend data displays data capture and retention, alarm status displays, sequence of events (with time stamp), control panel usage. Describe external analog/digit signal connectivity to Owner's remote control room. Include diesel engine and electric generation status data; include production rate/totalization data. Describe GenSet control display features (A-B PanelVIsion). |

# 2000 KW Diesel Generator Specification Sheet

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**Control Automatic Transfer Switch Command Signal**

| | |
|---|---|
| Diesel generator will be controlled from (later) | Local and Remote (PLC or DCS furnished by Purchaser) |

The electrical equipment to be mounted on or within the local control cabinet shall include, but not be limited to, the following:

| Description | Quantity | Unit |
|---|---|---|
| "Stop" and "Start" engine control switches with indicating lights | | Lot |
| Red mushroom "Emergency Stop" push button | | Each |
| Three-position (Off-Local Manual-Remote Auto/Manual) selector switch maintained in each position with overlapping contacts from Local Manual to Remote Auto/Manual, indicating light | | Each |
| Speed control switch (decrease-increase) | | Each |
| Voltage control switch (decrease-increase) | | Each |
| Set of generating unit accessories including meters, switches, and lights as required to properly operate the complete generating unit as recommended by the Supplier Reveal all these components and circuit configurations | | Lot |
| Annunciator, ISA Sequence A Capture sequence of shutdown events | | Each |
| Lot of fuses and terminal blocks | | Lot |
| Protective relays as described in "Electrical Equipment and Design" package Provide that package | | Lot |
| Voltage regulator Whose? Provide data/descriptions | | Each |
| Governor Whose? Provide data/descriptions | | Each |
| Synchronizing equipment Whose? Provide data/descriptions | | Lot |
| Potential transformers Whose? | | Each |
| Current transformers Whose? | | Each |
| Terminal blocks to terminate all external connections Whose? Test Switches? | | Lot |
| Terminal blocks for MV interconnections | | Lot |
| Excitation package Whose? Provide data/descriptions | | |
| Electrical connector crimp-lug whose? Terminal markings: describe | | |

| Description | Voltage | Quantity | Unit |
|---|---|---|---|
| Terminal blocks for one 3-phase ac power source | | Later | Lot |
| Terminal blocks for one single-phase ac power source | | Later | Lot |
| Terminal blocks for one dc power source | | Later | Lot |
| | | | |

The following is a minimum listing of analog input signals from the local control panel to the DCS that are required to be furnished by the Supplier

Generator volts Each phase
Generator amperes Each phase
Generator kVAR
Generator frequency
Generator kW
Generator Power Factor
Speed
Generator stator winding temperature (RTD) (one per phase)
Generator inboard bearing temperature (sleeve bearing only)
Generator outboard bearing temperature (sleeve bearing only)
Synchronous operation status.

## 2000 KW Diesel Generator Specification Sheet

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**Control (continued)**

The following is a minimum listing of digital output signals from the local control panel to the Owner's Building Automation system that are required to be furnished by the Supplier: Digial RS:485 TCP/LP (or other) signals are acceptable

Local-Remote selector switch in "Local Manual"
Local-Remote selector switch in "Remote Auto/Manual"
Local-Remote selector switch in "Off"
Generator diesel engine "Running"
Generator diesel engine "Not Running"
Generator diesel engine "Overspeed Alarm"
Voltage control at upper limit
Voltage control at lower limit
Speed control at upper limit
Speed control at lower limit
Local emergency stop push button actuated
Speed regulation in isochronous mode
Speed regulation in load sharing isochronous mode
Speed regulation in droop mode
Alarm outputs for each condition tripping the lockout relay(s)
Generator "Overvoltage Alarm"
Generator "Low Voltage Alarm"
Generator "Ready to Load" (at rated speed and voltage)
Generator "At Maximum Rated Load"
Generator fail to start alarm
Generator annunciator "Common Trouble Alarm"
Generator annunciator loss of dc power alarm
Generator normal shutdown in progress
Generator normal shutdown sequence time elapsed
Generator lockout relay reset
Generator lockout relay tripped
Generator synchronization package outputs
Generator Auto-Start disabled
Generator emergency shutdown initiated

The following is a minimum listing of digital local control panel input signals from the Owner's B.A.S. to the local control panel that may be required to be furnished by the Supplie

Generator start command (momentary contact)
Generator stop command (normal shutdown) (momentary contact)
Generator voltage increase (momentary contact)
Generator voltage decrease (momentary contact)
Generator speed increase (momentary contact)
Generator speed decrease (momentary contact)
Generator droop mode select (maintained contact)
Generator isochronous mode select (maintained contact)
Generator load sharing isochronous mode select (maintained contact)

| | |
|---|---|
| Enclosure protection | NEMA 1, gasketed |
| Additional Requirements | |

# SECTION 263353

# STATIC UNINTERRUPTIBLE POWER SUPPLY

## SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:

    a. Surge suppression.
    b. Input harmonics reduction.
    c. Rectifier-charger.
    d. Inverter.
    e. Static bypass transfer switch.
    f. Battery with support stands and battery disconnect device.
    g. External maintenance bypass/isolation switch.
    h. Output isolation transformer.
    i. Remote UPS monitoring provisions.
    j. Battery wet cell charging system with monitoring.
    k. Remote monitoring connectivity.
    l. Cooling air fan arrays with ductwork
    m. The owner shall provide a suitable UPS enclosure with thermal and sound attenuation features
    n. The UPS enclosure will be provided with owner supplied HVAC system to maintain a uniform 73°F +/- 3°F for UPS operations and battery storage.
    o. The DC storage battery enclosure hydrogen evolution SCFH data provides a basis for an owner supplied NEMA 7 explosionproof ventilation fan.
2. Two complete UPS systems (Owner Purchased) Toshiba G8000 Series System Available from Ancona Controls.com; Houston, Texas 77041 are considered in this 263353 Specification
    a. Part Number: T8MS3K30KK6XSN
        1) Engineering Building UPS 300 kVA/270 kW rated unit
        2) Quantity One G8000MM Standard System:
            a) 480V 3ϕ 60HZ Input
            b) 480V 3ϕ 60HZ Maintenance Output Voltage
            c) 480V 3ϕ 60HZ UPS Output Voltage
            d) 3ϕ 4 wire
            e) Battery: Charging Circuit DC Voltage
               Charging Circuit: ~ 40 Amps

H$_2$ Gas Evolution __________ SCFH

f) Heat Rejection: 61,000 BTU/Hr

g) Noise: ~ 78 dBA

h) Efficiency: ~ 93.8%

b. Part Number: T8MS3K10KK6XSN

1) Physics Building UPS 100 kVA/80 kW rated unit

2) Quantity One G8000MM Standard System:

a) 208V 3Φ 60HZ Input

b) 208V 3Φ 60HZ Maintenance Output Voltage

c) 208V 3Φ 60HZ UPS Output Voltage

d) 3Φ 4 wire

e) Battery: Charging Circuit DC Voltage

Charging Circuit: ~ 13 Amps

H$_2$ Gas Evolution __________ SCFH

f) Heat Rejection: 18,500 BTU/Hr

g) Noise: ~ 68 dBA

h) Efficiency: ~ 93.7%

## 1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. HVAC: Heating, Ventilation and Air Conditioning

C. LCD: Liquid-crystal display.

D. LED: Light-emitting diode.

E. PC: Personal computer.

F. THD: Total harmonic distortion.

G. UPS: Uninterruptible power supply.

## 1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to City of Detroit BOCA dataset.

1. 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**."

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, electrical duration ratings, and performance.

B. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show operations and termination access, workspace, and clearance requirements; details of control display panels; and battery arrangement.
2. Wiring Diagrams: For power, signal, and control wiring. (one-line with all secondary and monitoring circuit equipment details).
3. Provide heat resection rate data. (consider a 73° F +/- 3° F enclosure space).
4. Provide wet cell storage battery hydrogen evolution into a closed space. State ventilation requirement data. (consider a 73°F +/- 3°F environment).

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified **testing agency provide the test QA results data.** .

B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

C. Manufacturer Certificates: For each product, from manufacturer.

D. Factory Test Reports: Comply with specified requirements.

E. Field quality-control reports.

F. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

G. Warranties: Sample of special warranties.

## 1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and systems maintenance manuals.

## 1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Three each for each type and rating.
2. Cabinet Ventilation Filters: Two complete set(s).

## 1.9 QUALITY ASSURANCE

A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

D. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

E. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

## 1.10 WARRANTY

A. Not Chosen, Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

| Discharge Rate | Discharge Duration | Discharge End Voltage | Cycle Life |
|---|---|---|---|
| 8 hours | 8 hours | 1.67 | 6 cycles |
| 30 minutes | 30 minutes | 1.67 | 20 cycles |
| 15 minutes | 45 seconds | 1.67 | 120 cycles |

2. Not Chosen, Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

| Discharge Rate | Discharge Duration | Discharge End Voltage | Cycle Life |
|---|---|---|---|
| 8 hours | 8 hours | 1.67 | 40 cycles |
| 30 minutes | 30 minutes | 1.67 | 125 cycles |
| 15 minutes | 1.5 minutes | 1.67 | 750 cycles |

3. Chosen Battery Application, Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

| Discharge Rate | Discharge Duration | Discharge End Voltage | Cycle Life |
|---|---|---|---|
| 8 hours | 8 hours | 1.75 | 40 cycles |
| 1 hour | 1 hour | 1.75 | 80 cycles |
| 15 minutes | 45 seconds | 1.67 | 2700 cycles |

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: [**Two**] [**Three**] <**Insert number**> years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Normal AC input Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the

load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.

5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
3. Relative Humidity: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet (1220 m).

## 2.2 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is **50** percent unbalanced continuously.

B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is **15** minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus **15** percent from nominal voltage.

D. Overall UPS Efficiency: Equal to or greater than >93% percent at 100 percent load.

E. Maximum Acoustical Noise: 78dBA, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 48 inches from nearest surface of component enclosure.

F. Maximum Energizing Inrush Current: **Six** times the full-load current.

G. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to **5** percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
2. Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

J. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

K. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

L. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.

M. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:

1. 50 Percent: Plus or minus 5 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

N. Input Power Factor: A minimum of **0.90** lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.

O. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

## 2.3 UPS SYSTEMS

A. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

B. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

C. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

D. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch**, and maintenance bypass/isolation switch**. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressor filters tested according to IEEE C62.41.1 and IEEE C62.41.2, **Category C**.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

E. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

F. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future **25** percent increase in UPS capacity.

G. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

H. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

I. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

## 2.4 RECTIFIER-CHARGER

A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

   1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

## 2.5 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output.

B. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

## 2.6 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

## 2.7 BATTERY

A. Not chose, Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.

  1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

  1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

C. Chosen battery application, Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on **three-tier,** acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.

D. Toshiba (Ancona)

E. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

## 2.8 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: **Plain-language messages on a digital LCD or LED**.

  1. Quantitative indications shall include the following:

    a. Input voltage, each phase, line to line.
    b. Input current, each phase, line to line.

  c. Bypass input voltage, each phase, line to line.
  d. Bypass input frequency.
  e. System output voltage, each phase, line to line.
  f. System output current, each phase.
  g. System output frequency.
  h. DC bus voltage.
  i. Battery current and direction (charge/discharge).
  j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

  a. Normal operation.
  b. Load-on bypass.
  c. Load-on battery.
  d. Inverter off.
  e. Alarm condition.

3. Alarm indications shall include the following:

  a. Bypass ac input overvoltage or undervoltage.
  b. Bypass ac input overfrequency or underfrequency.
  c. Bypass ac input and inverter out of synchronization.
  d. Bypass ac input wrong-phase rotation.
  e. Bypass ac input single-phase condition.
  f. Bypass ac input filter fuse blown.
  g. Internal frequency standard in use.
  h. Battery system alarm.
  i. Control power failure.
  j. Fan failure.
  k. UPS overload.
  l. Battery-charging control faulty.
  m. Input overvoltage or undervoltage.
  n. Input transformer overtemperature.
  o. Input circuit breaker tripped.
  p. Input wrong-phase rotation.
  q. Input single-phase condition.
  r. Approaching end of battery operation.
  s. Battery undervoltage shutdown.
  t. Maximum battery voltage.
  u. Inverter fuse blown.
  v. Inverter transformer overtemperature.
  w. Inverter overtemperature.
  x. Static bypass transfer switch overtemperature.
  y. Inverter power supply fault.
  z. Inverter transistors out of saturation.
  aa. Identification of faulty inverter section/leg.
  bb. Inverter output overvoltage or undervoltage.
  cc. UPS overload shutdown.

dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

    a. Inverter on-off.
    b. UPS start.
    c. Battery test.
    d. Alarm silence/reset.
    e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts. “e-stop”

## 2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full UPS load current.

D. Mounting Provisions: **Internal to system cabinet**.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

## 2.10 OUTPUT ISOLATION TRANSFORMER

A. Description: **Unit** with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately **9**.
2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.
6. Coil Leads: Physically arranged for minimum interlead capacitance.
7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.

## 2.11 OUTPUT DISTRIBUTION SECTION

A. Panelboards: Comply with "Panelboards" except provide assembly integral to UPS cabinet.

## 2.12 MONITORING BY REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate **five** basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication. Describe HMI display interface pages and operations display data.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

## 2.13 MONITORING BY REMOTE COMPUTER

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units or modems for data transmission via RS-232 link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

## 2.14 BASIC BATTERY MONITORING

A. Toshiba UPS system.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

D. Annunciation of Alarms: At UPS control panel.

## 2.15 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

   1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
   2. Connections for data transmission via RS-232 link, [**network interface and modem and** external signal wiring to **electrical power monitoring and control equipment**. External signal wiring and computer are not specified in this Section.
   3. PC-based software designed to store and analyze battery data. Software compiles reports on individual-cell parameters and total battery performance trends, and provides data for scheduling and prioritizing battery maintenance.

B. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:

   1. Total battery voltage and ambient temperature.
   2. Individual-cell voltage, impedance, and temperature. During battery-discharging events such as utility outages, measures battery and cell voltages timed to nearest second.
   3. Individual-cell electrolyte levels.

## 2.16 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
2. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to initiate **local** and **remote** alarm for **battery discharge events abnormal temperature abnormal battery voltage or temperature**.
5. Memory: Stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading of data to a portable PC.
7. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

## 2.17 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use **actual batteries that are part of final installation battery testing**. Include the following:

   1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
   2. Full-load test.
   3. Transient-load response test.
   4. Overload test.
   5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice. WSU site test demonstrations shall be conducted during the Monday through Friday normal work week between 0830-1700 hours. WSU will observe testing. The seller shall submit the QA program test plan for WSU acceptance.

C. Report test results. Include the following data:

   1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
   2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
   3. List of instruments and equipment used in factory tests.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

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

## 3.2 INSTALLATION

A. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

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

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

## 3.3 GROUNDING

A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

## 3.4 IDENTIFICATION

A. Identify all components and unique destination wiring according to "Identification for Electrical Systems."

1. Identify each battery cell individually.

## 3.5 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections.

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

D. Tests and Inspections:

  1. Comply with manufacturer's written instructions.
  2. Inspect interiors of enclosures, including the following:

    a. Integrity of mechanical and electrical connections.
    b. Component type and labeling verification.
    c. Ratings of installed components.

  3. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
  4. Test manual and automatic operational features and system protective and alarm functions.
  5. Test communication of status and alarms to remote monitoring equipment.
  6. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the UPS unit's rating. Use instruments calibrated within the previous **six months** according to NIST standards.

    a. Simulate malfunctions to verify protective device operation.
    b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
    d. Test output voltage under specified transient-load conditions.
    e. Test efficiency at 50, 75, and 100 percent of rated loads.
    f. Test remote status and alarm panel functions.
    g. Test battery-monitoring system functions.

E. Seismic-restraint tests and inspections shall include the following:

  1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
  2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

F. The UPS system will be considered defective if it does not pass tests and inspections.

G. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

H. Prepare test and inspection reports.

## 3.7 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated **for each UPS system**.

B. Monitoring and Testing Schedule: Perform monitoring and testing in **a single 10-day period** scheduled for each of the two UPS units: 300 KVA/270 KW Engineering Building, and 100KVA/80KW Physics Building.

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.

D. Monitoring and Testing Procedures[ **for Each Test Period**]:

1. Exploratory Period: For the first [**two**] <**Insert number**> days[ **of the first scheduled monitoring and testing period**], make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.

2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
    c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
    d. Using loads and devices available as part of the facility's installed systems and equipment[ **and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    e. Using temporarily connected resistive/inductive load banks[ **and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.

4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in [**each** ]report:

1. Description of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendation for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

## 3.8 DEMONSTRATION

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

END OF SECTION 263353

# SECTION 263600 – AUTOMATIC TRANSFER SWITCHES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.
3. Nonautomatic transfer switches.
4. Remote annunciation systems.
5. Remote annunciation and control systems.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories. Monitoring circuit detail, alarm, actuator deploy and restore data, and timing function data.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548.16 "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.

C. Field Quality Assurance Program-control reports.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

## 1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent 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.

C. Source Limitations: Obtain through one source from a single manufacturer.

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

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

## 1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others until written permission is given by Owner.

## 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 Section 033000 "Cast-in-Place Concrete."

# PART 2 - PRODUCTS

## 2.1 MANUFACTURED UNITS

A. Contactor Transfer Switches:

Square D (Schneider), General Electric, Culter-Hammer (Eaton).

## 2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

1. Float type rated 2A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

H. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

1. Fully automatic make-before-break operation.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure or degredation of power source serving load initiates automatic break-before-make transfer.

I. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

J. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

K. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

L. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.

b. Push-button programming control with digital display of settings.

c. Integral battery operation of time switch when normal control power is not available.

## 2.4 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:

1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Indication of switch position.
3. Indication of switch in test mode.
4. Indication of failure of digital communication link.
5. Key-switch or user-code access to control functions of panel.
6. Control of switch-test initiation.
7. Control of switch operation in either direction.
8. Control of time-delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

C. Remote Annunciation and Control Panel: Solid-state components. Include the following features:

1. Controls and indicating lights grouped together for each transfer switch.
2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
3. Digital Communication Capability: Matched to that of transfer switches supervised.
4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

## 2.5 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. In accordance with a Quality Assurance Program Test Plan document (witnesses and signed off). Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

  1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Section 260553 "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

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

### 3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

  1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

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

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 017900 "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

## AUTOMATIC TRANSFER SWITCH
## COMMON ATS TECHNICAL REQUIREMENTS

| COMPONENT IDENTIFIER | BUILDING | RATING | MONITOR/CONTROL FEATURES | ALARM FEATURES AUXILLARY CONTACTS | SERIAL DATA COMMUNICATIONS DISPLAY HMI | NOTES |
|---|---|---|---|---|---|---|
| ATS - 4<br>NEMA 3R<br>S.E. Rated | Engineering<br>EDC<br>G-2 generator to LSIG breaker tie to main 480V switchboard "SWBD-MSB". | 480V 3000AMP | AMPS over/under<br>VOLTS over/under<br>Frequency (wave form)<br>VARS (limit)<br>Event (time stamps)<br>Event (off normal)<br>Reclose (closed transition)<br>Reclose (manual administrated)<br>Operations (cycle count) *<br>Auto/manual/bypass<br>* Closed transition duty cycle<br>* Microprocessor adjustable controller<br>* Engine exercizer | Event register: alarms, each occurance<br>Each acknowledge (time history)<br>Events include city power (off normal)<br>Testing cycles (scheduled)<br>ATS diagnosis and repair<br>ATS unit-high-temperature<br>Auxilliary hard electrical contacts for buyer's building automation system (B.A.S) | Required: communication protocols.<br>Identify the seller's capabilities. (RS-485 and other)<br>Data stream suitable to display ATS man-machine real-time HMI display data feed to buyer's remote site HMI.<br>Auto-diagnostic ATS maintenance service; dial-up capability (C.I.P. sensitive)<br>Operational made display (and others)<br>Data logging capabilities | Notes 1: CT & PT circuit interposed sensor hardware and design requirements by supplier.<br>Notes 2:Cabling and terminations by supplier.<br>Notes 3: ATS alternative feed is T-1 13.2 KV to 480V transformer |
| ATS 5<br>NEMA 3R<br>S.E. Rated | Engineering<br>100/300 | 4800V 1200AMP<br>G-2 Generator to EDC MV Bus via: new 2000 KW step-up transformer.<br>ATS alternative the feed is 4800V MV PLD city bus. | | | | |

NOTE: REFER TO ATS SPCIFICATION 263600 PERTAING TO ADDITIONAL FEATURES, ALARM FEATURES AND COMMUNICATIONS

**Noted:** Additional EDC Building Auto Transfer Switches exist, however their electrical duties are solely connected within the 500 KW "G-1" existing 480V 3Ø emergency GenSet. "G-1" GenSet circuit configurations follow: ATS-1: MCC-B Motor Control, ATS-2: Lighting, Emergency, ATS-3: Fire Pump FP-1 Duty, Shall be retained as circuited in 2014

**Note 1:**

- Automatic Transfer Switch co-ordination/control wired circuits now exist that involve ATS-1, ATS-2, ATS-3 that monitor power conditions, (or degraded power, or non-available power) from PLD 15KV (rated) Russell Substations 2 or 2A (Nominally, 4800v 3Ø 60HZ 3W GND sources.
- The existing G-1 500 KW Emergency standby Diesel GenSet will be retained as the sole emergency standby 480 Volt alternative power source serving those three ATS switches. Whenever automatic transfer switch monitoring circuits detect “faulted power conditions” they transfer power from the city PLD power source, then will connect the G-1 GenSet to the three existing designated loads. (ATS-1: MCC B EF fans & elevators; ATS-2: LP-1XA; and LP-3XA; and ATS-3: (FP-1 fire pump). All the 500 KW G-1 Diesel GenSet loads will be retained as they are circuited in 2014.
- No parallel GenSet operation, nor synchronized connected circuits involving the new G-2 diesel GenSet will be provided to those three 500 KV G-1 loads.

**Note 2:**

- The new G-2 emergency standby diesel generator 2000 KW Diesel GenSet will be connected to the existing EDC building load(s) using the new automatic transfer switch ATS-4 designated to supply 480V 3Ø 60HZ power to the existing SWBD-MSB switchboard. The ATS-4 with its power condition monitoring circuits will be interposed between the T-1 2000 KVA transformer 480V 3Ø 60HZ 4 wire secondary output existing wired circuits and the SWBD-MSB LS1G main breaker (3200 AF/3000AT drawout C.B.). 480 volt 3 phase cabling termination modifications will be
- ATS-4 power condition monitoring, (when degraded power conditions exist), will initiate the 2000KW GenSet to start supplying 480V 3Ø 60HZ building power to SWBD-MSB connected electrical loads.
- No parallel GenSet operation, nor synchronization with the existing G-1 GenSet, nor its 480V 3Ø 60HZ three designated loads will be circuited.

**Note 3:**

- Communication between existing ATS 1 / ATS 2 and ATS 4 is required to prevent Existing ATSs from returning to normal position via a delayed contact until ATS 4 returns to normal.
- The general control scheme involves G-1 and G-2 starting due to a power outage event. Transfer switches 1,2,3 and 5 are then closed to place their respective loads on generator power. Transfer switch 4 is then allowed to switch to generator. In doing so, ATS 1,2 and 3 will recognize G-2 power as viable utility power and will want to return to normal. A delayed contact connection to ATS 4 will prevent ATS 1 and 2 form returning to normal until ATS 4 recognized viable utility power and returns to normal.

PHYSICS BUILDING RELIABILITY
CAI 320003-S-1

AUTOMATIC TRANSFER SWITCH
COMMON ATS TECHNICAL REQUIREMENTS

| COMPONENT IDENTIFIER | BUILDING | RATING | MONITOR/CONTROL FEATURES | ALARM FEATURES AUXILLARY CONTACTS | SERIAL DATA COMMUNICATIONS DISPLAY HMI | NOTES |
|---|---|---|---|---|---|---|
| **ATS -1**<br>Nema 3R<br>S.E. Rated | Physics | 480V 3Ø 1600AMP | AMPS over/under<br>Volts over/under (surge)<br>Frequency (wave form)<br>VARS (limit) | Event register: alarms, each occurrence<br>Each acknowledge (time history)<br>Events include city power (off normal)<br>Testing cycles (scheduled)<br>ATS diagnosis and repair ATS unit-high-temperature<br>Auxilliary hard electrical contacts for buyer's building automation system (B.A.S) | Required: communication protocols.<br>Identify the seller's capabilities (RS-485 and<br>Data stream suitable to display ATS man-machine real-time HMI display data feed to buyer's remote site HMI<br>Auto-diagnostic ATS maintenance service; dial-up capability (C.I.P. sensitive)<br>Operational mode display (and others)<br>Data logging capabilities | * Auto/manual/bypass operations<br>* Closed transition duty cycle.<br>* Microprocessor adjustable controller |
| **ATS-2**<br>Nema 3R<br>S.E. Rated | Physics | 208V 3Ø 3000AMP | Event (time stamps)<br>Event (off-normal)<br>Reclose (closed transition)<br>Reclose (manual administrated)<br>Operations (cycle count) | | | |

NOTE: REFER TO ATS SPCIFICATION 263600 PERTAING TO ADDITIONAL FEATURES, ALARM FEATURES AND COMMUNICATIONS

**Soil and Materials Engineers, Inc.**
The Kramer Building
43980 Plymouth Oaks Blvd.
Plymouth, MI 48170-2584

tel (734) 454-9900
fax (734) 454-0629

www.sme-usa.com

July 21, 2014

Mr. Bill McVea
Facilities Planning and Management
Wayne State University
5454 Cass Avenue
Detroit, Michigan 48202

*Via electronic mail:* fd9315@wayne.edu *(PDF file)*

RE: Geotechnical Evaluation Report
Proposed Electrical Pads - Wayne State University
Detroit, Michigan
SME Project No. 069961.00

Dear Mr. McVea:

Soil and Materials Engineers, Inc. (SME) has completed a geotechnical evaluation for the proposed electrical pads on the campus of Wayne State University (WSU) in Detroit, Michigan. This report presents the results of our observations and analyses, and our recommendations for subgrade preparation and earthwork. Additionally, our report presents a short discussion on construction considerations related to the geotechnical conditions disclosed by the borings.

SME did this evaluation in accordance with the scope of services outlined in our Proposal No. P01423.14 for Geotechnical Evaluation Services dated May 29, 2014. Refer to that proposal for the specific scope of services. Mr. Bill McVea of WSU authorized this evaluation per the Agreement between the University and Contractor for Construction Services signed by SME June 4, 2014.

## PROJECT DESCRIPTION

The project includes the design and construction of several electrical equipment pads on the campus of WSU in Detroit, Michigan. The new electrical pads will be located near the following campus buildings.

- Physics – 666 W. Hancock
- Science Hall – 5045 Cass Avenue
- Shapero Hall – 5501 Gullen Mall
- Engineering – 5050 Anthony Wayne
- Deroy – 5200 Anthony Wayne
- Chatsworth – 630 Williams Mall
- Pharmacy – 259 Mack
- Elliman – 421 E. Canfield

We understand the electrical equipment pads will consist of about 8- to 10-inch thick concrete mats situated on a prepared subgrade. We did not receive other design information when we prepared this report. Based on our site visit, the areas for the pads are either grass covered or paved.

## EVALUATION PROCEDURES

SME completed eight (8) borings for the project on July 9 and 10, 2014. The borings extended 15 to 25 feet below the ground surface for a total of 130 linear feet of drilling. WSU determined the number, locations, and depths of the borings. SME staked the locations of the borings in the field with Mr. Bill McVea of WSU using existing site features as reference. We depict the approximate boring locations on the attached Boring Location Diagrams (Figures 1 through 8).

We drilled the borings using a truck-mounted rotary-type drill rig and advanced them using solid-stem augers. The borings included sampling based upon the Split-Barrel Sampling procedure. Our drillers sealed recovered split-barrel samples in glass jars. We recorded groundwater levels during and immediately after completion of the borings. The boreholes were backfilled with excess auger cuttings upon completion of drilling and sampling. Therefore, SME did not obtain long-term groundwater levels from the borings. We sent the soil samples recovered from the field exploration to our laboratory for further observation and testing.

Our laboratory-testing program consisted of visual soil classification of the recovered samples, along with moisture content and hand penetrometer tests on portions of cohesive samples obtained. The appended Laboratory Testing Procedures provide general descriptions of the laboratory tests given above.

SME visually classified the soil samples in accordance with the Unified Soil Classification System (USCS). We show the estimated group symbol, according to the USCS, in parentheses following the textural description of the various strata on the boring logs attached to this letter. The appended Boring Log Terminology sheet includes a brief summary of the method of describing the soil and assigning an appropriate USCS group symbol.

Upon completion of the laboratory testing, we prepared the attached boring log that includes materials encountered, penetration resistances, pertinent field observations made during the drilling operations, and the results of certain laboratory tests. We developed the soil descriptions included on the boring logs both visual classification and the results of laboratory tests, where applicable.

Soil samples retained over a long time, even in sealed jars, are subject to moisture loss and are no longer representative of the conditions initially encountered in the field. Therefore, we normally retain soil samples in our laboratory for 60 days and then dispose them, unless instructed otherwise.

## SUBSURFACE CONDITIONS

The soil conditions encountered at the boring locations generally consisted of surface topsoil or Portland cement concrete overlying sand and/or clay fill underlain by natural clays to the explored depths of the borings.

Topsoil thickness varied ranging from about 1 inch to 24 inches at borings B1, B4, B7, and B8. The topsoil encountered in boring B4 within the upper two feet of subgrade had an organic content of about 4 percent which we consider slightly to moderately organic.

The Portland cement concrete thickness at borings B2, B3, B5, and B6 varied from about 5 to 6 inches.

We encountered sand fill below the topsoil and concrete in borings B1, B3, B5, B6, and B8 extending about 3.5 to 6.5 feet below the ground surface. Standard Penetration Test (SPT) resistances (N-values) in the sand fill varied from about 7 to 22 blows per foot (bpf) indicating a loose to medium dense condition. The sand fill contained topsoil layers in boring B3 and trace amounts of brick fragments in boring B1. The organic content of the sand fill in boring B1 was 2.7 percent, which we consider slightly organic.

We encountered clay fill below the topsoil and pavements in borings B2, B4, and B7 and below the sand fill in borings B1 and B6. The clay fill extended about 3 to 12 feet below the ground surface. Undrained shear strength estimates of the clay fill varied from about 1.0 kips per square foot (ksf) to greater than 4.5 ksf indicating a stiff to hard consistency. Measured moisture contents varied from about 9 to 21 percent. We observed topsoil layers in the clay fill in borings B2, B4, and B6 along with trace amounts of cinders and brick fragments.

We encountered natural clay below the fill extending to the explored depths of the borings. Undrained shear strength estimates of the natural clays varied from about 1.0 ksf to greater than 4.5 ksf indicating a stiff to hard consistency. However, the natural clays are generally very stiff to hard and decrease in strength with depth. Measured moisture contents varied from about 9 to 21 percent.

The soil profile described above and included on the appended boring logs are generalized descriptions of the conditions encountered. We intend the stratification depths described above and shown on the boring logs to indicate a zone of transition from one soil type to another. They generally do not show exact depths of change from one soil type to another. We base the soil descriptions on visual classification of the soils encountered. Soil conditions may vary between or away from the boring locations. Please refer to the boring logs for the soil conditions at the specific boring locations.

Consider thickness measurements of surficial materials reported on the boring logs (e.g., topsoil and pavements) approximate. If accurate thickness measurements are required of the topsoil and asphalt concrete for inclusion in bid documents or purposes of design, do additional evaluations such as test pits and/or coring.

It is sometimes difficult to distinguish between fill and natural soils based on samples and cuttings from small-diameter boreholes, especially when portions of the fill do not contain man-made materials, debris, topsoil or organic layers, and when the fill appears similar in composition to the local natural soils. Therefore, consider the delineation of fill described above and on the appended boring logs approximate only. You could make a more comprehensive evaluation of the extent and composition of the fill by reviewing former site topography plans (such as grading plans from the original construction), aerial photographs, and other historic site records and by observing test pit excavations.

The SME driller measured and recorded groundwater levels in the borings during the drilling operations from about 3 to 5.5 feet below the ground surface in borings B1, B5, and B7. Immediately following the drilling operations, the driller measured and recorded groundwater levels from about 13 to 14 feet below the ground surface in borings B1 and B7. The groundwater encountered appears perched within the fill overlying less permeable clays.

Expect groundwater levels, perched groundwater, and the potential rate of infiltration into excavations to fluctuate throughout the year, based on variations in precipitation, evaporation, run-off, and other factors. The groundwater levels indicated by the borings represent conditions when the readings were taken. The actual groundwater levels at the time of construction may vary.

## ANALYSIS AND RECOMMENDATIONS

We encountered sand fill and clay fill at the boring locations extending about 3 to 12 feet below the ground surface. There is an increased risk of cracking and settlement of mat foundations and slabs constructed over undocumented and uncontrolled fill. Completely remove the existing fill to significantly reduce this risk from within the electrical pad areas and replace it with properly placed and compacted engineered fill. Partial removal of the uncontrolled fill should result in reducing (but not eliminating) the risk of poor mat and slab performance. The more uncontrolled fill removed, the less the risk becomes. However, since the mats are lightly loaded, we believe there is a low risk of poor performance assuming the exposed subgrade is properly prepared and tested.

However, if you are not willing to accept the risk of potentially poor mat and slab performance then at least remove the existing fill with organics such as the fill encountered in borings B2, B3, and B4 below the proposed electrical pad footprints. We expect the mass excavations at these locations to extend from about 3.5 to 6 feet below the ground surface.

After removing existing fill, we recommend placing and compacting engineered fill back to the design subgrade elevation. We recommend engineered fill for the undercuts consist of 1 to 3 inch size crushed concrete with less than 7 percent fines topped with a 4-inch thick layer of MDOT 21AA crushed limestone. Otherwise, engineered fill for the undercuts could consist of MDOT Class II sand. We recommend you suitably compact the crushed concrete with the excavator bucket. MDOT 21AA crushed limestone and MDOT Class II sand must be compacted to a minimum of 95 percent of the maximum dry density as determined by the modified Proctor test. We recommend placing engineered fill and/or crushed concrete fill in lifts of no more than about 9 inches in loose thickness.

We recommend a minimum of 4 inches of MDOT 21AA material below the substation pads regardless if mass undercutting occurs. Thicker sections of MDOT 21AA may be required depending on the mat thickness. Please contact SME for further discussion once you design the pads.

### Construction Considerations

We do not expect significant groundwater seepage for electrical pad construction. For most excavations extending about 1 to 2 feet below the perched groundwater levels, we anticipate standard sump pit and pumping procedures will be adequate to control these accumulations, on a localized basis. A working surface of crushed aggregate or crushed concrete may be required to protect the exposed subgrade where seepage is present.

The exposed subgrade soils can be easily disturbed due to weather and activity on-site. Therefore, the contractor should remove standing water from areas where water collects and prevent surface water from reaching the foundation excavations and areas of prepared subgrade. Also, to reduce the potential of subgrade disturbance across the site, construction traffic should be restricted to special construction roads, and not be allowed to randomly traffic the site. Disturbed soils may have to be moisture conditioned and recompacted in-place, or undercut and replaced with engineered fill. Moisture conditioning may not be feasible during seasonally cold and wet times of the year, resulting in a potential need for additional imported fill if the work is done between the late fall and early spring seasons. Protect areas of exposed subgrade at the site by placing crushed concrete or crushed aggregate on it. Under adverse weather conditions, the placement of a geotextile fabric for separation on the exposed subgrade may be beneficial. Doing site work during the drier summer months should reduce the potential for subgrade disturbance and the need for improvement of the subgrade.

The contractor must take precautions to protect existing utilities, pavements, and any neighboring structures during construction. Exercise care during the excavating and compacting operations so that undermining and/or excessive vibrations do not cause undesirable movement of the existing utilities, pavements, and/or structures.

Based on the potentially variable depths of existing fill within the proposed pad areas, we recommend the bid documents require prospective contractors to include unit prices for excavating existing fill, organic soils, disturbed soils and other unsuitable soils and replacing them with engineered fill. We recommend establishing a contingency in the construction budget for the additional earthwork. We can verify actual quantities of additional earthwork during construction by measuring excavation volumes, counting truck loads, or a combination of methods. SME can also assist with estimating quantities for establishing the contingency, if desired.

The contractor must provide a safely sloped excavation or an adequately constructed and braced shoring system in accordance with federal, state and local safety regulations for individuals working in an excavation that may expose them to the danger of moving ground. If material is stored or heavy equipment is operated near an excavation, appropriate shoring must be used to resist the extra pressure due to the superimposed loads.

Contractors doing subsurface work (e.g., earthwork, utilities, foundations, etc.) shall review available environmental assessment information and develop a plan to appropriately handle and dispose of impacted soil and groundwater. Manage all soil and groundwater generated from construction activities in accordance with applicable environmental regulations and the Owner’s soil and groundwater management plan for the site.

We appreciate the opportunity to serve you during this phase of the project. If there are questions concerning this report, or if we can be of further service, please contact us.

Very truly yours,

**SOIL AND MATERIALS ENGINEERS, INC.**

Kevin L. Wilk

Kevin L. Wilk, PE
Senior Project Engineer

Larry P. J

Larry P. Jedele, PE, D.GE
Principal

| | |
|---|---|
| Attachments: | Boring Location Diagrams (Figures 1 through 8) |
| | Boring Log Terminology |
| | Boring Logs (B1 through B8) |
| | Important Information about your Geotechnical Engineering Report |
| | General Comments |
| | Laboratory Testing Procedures |

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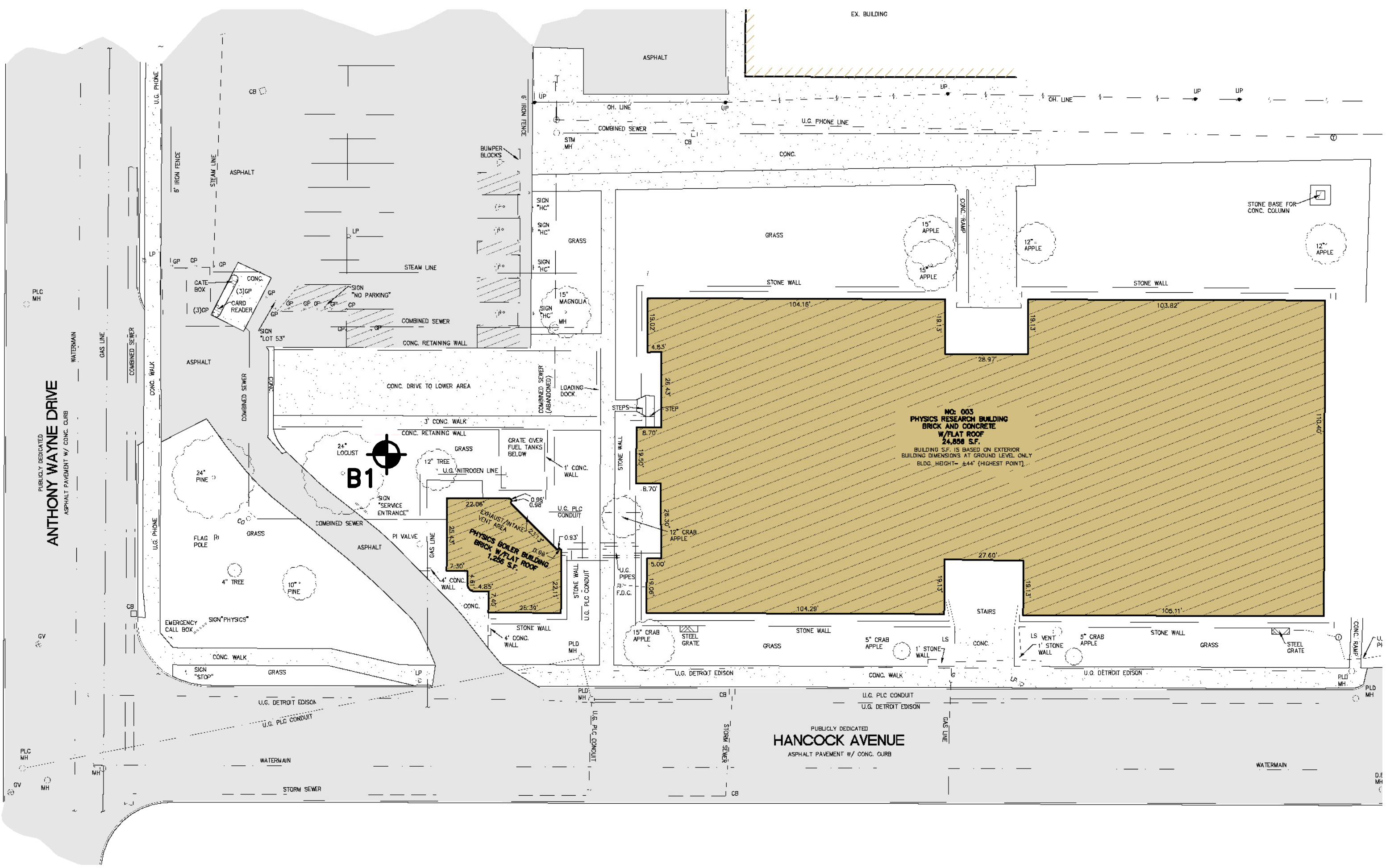
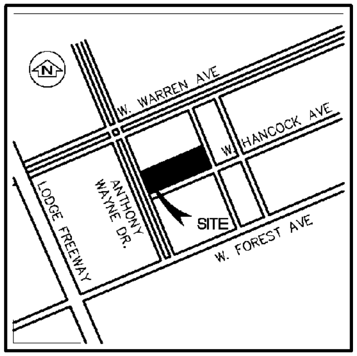


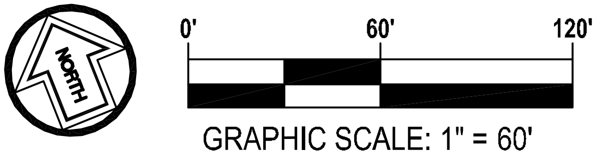


## LOCATION MAP

NTS

# LEGEND

⌖ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 60'

NOTE:
DRAWING INFORMATION TAKEN FROM SITE SURVEY (DATED 06-24-2014) PREPARED BY NOWAK & FRAUS ENGINEERS.

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|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 60' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
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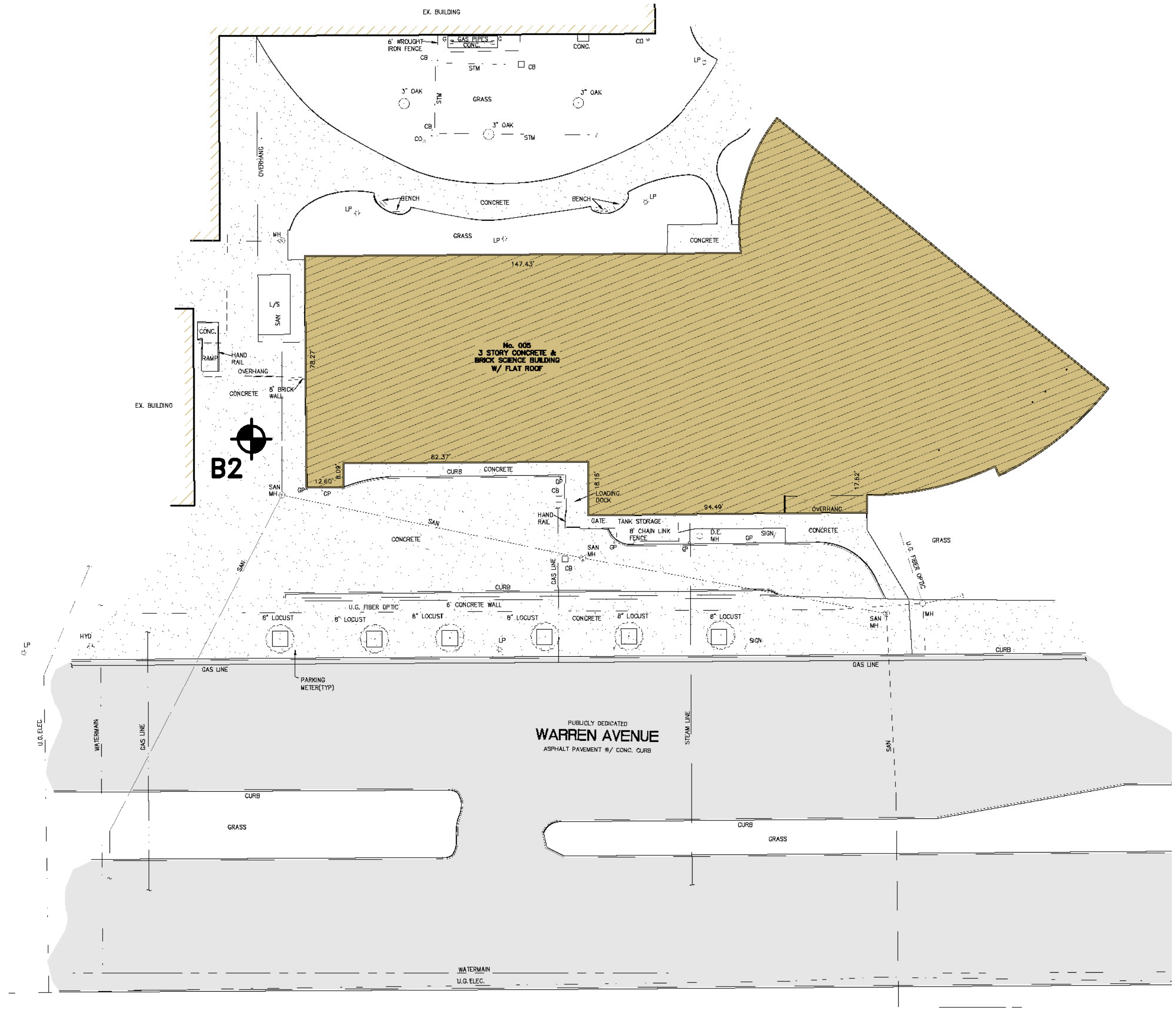
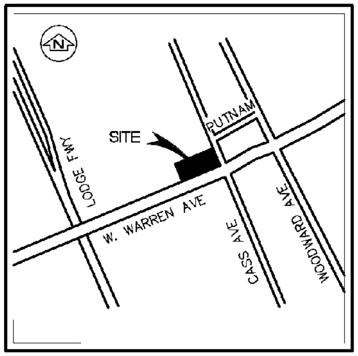
Figure No. 1



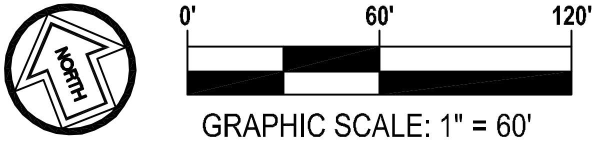


## LOCATION MAP

NTS

## LEGEND

⊕ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 60'

NOTE:
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|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 60' |
| Project | 069961.00 |

**BORING LOCATION DIAGRAM**
**PROPOSED ELECTRICAL PADS**
**WAYNE STATE UNIVERSITY**
**DETROIT, MICHIGAN**

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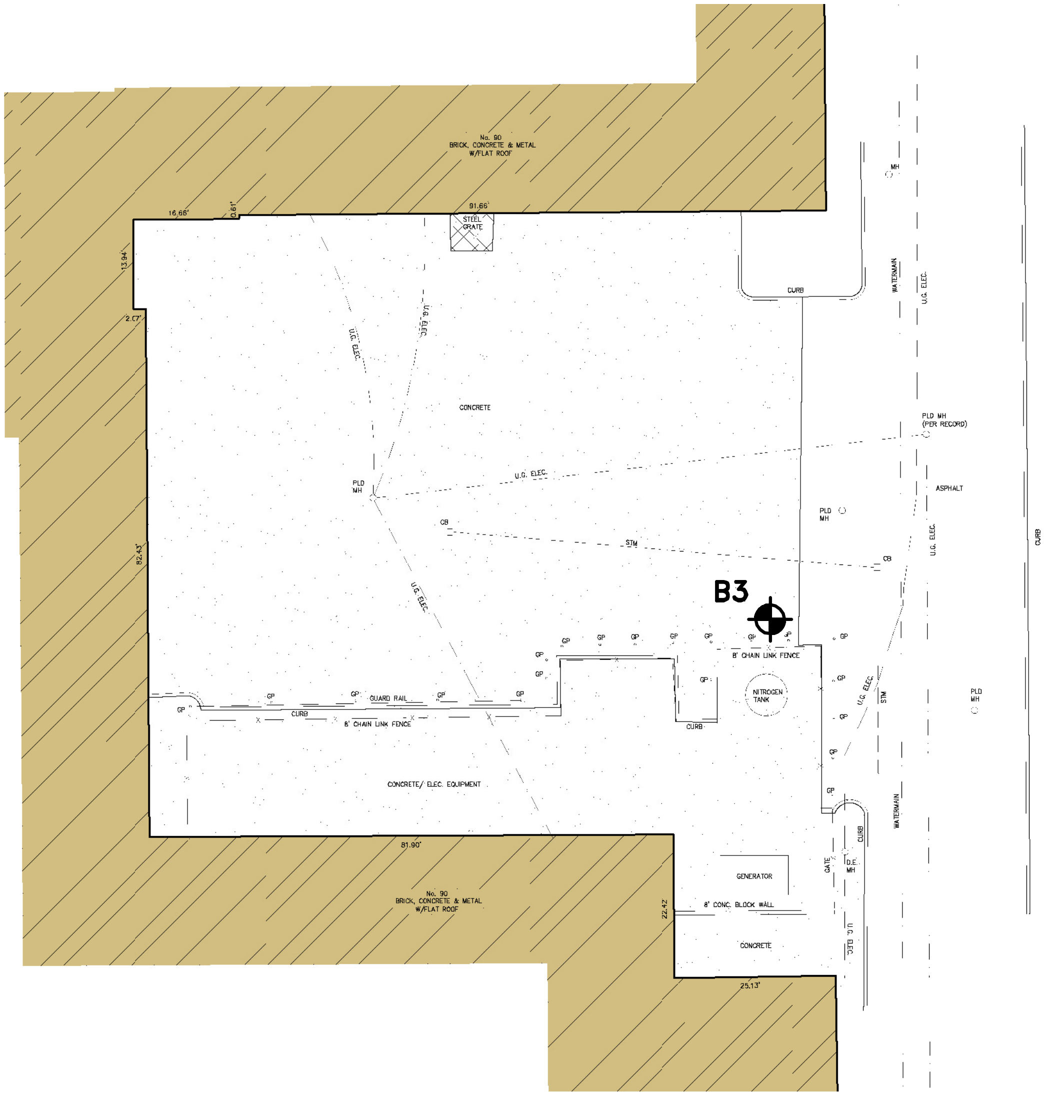
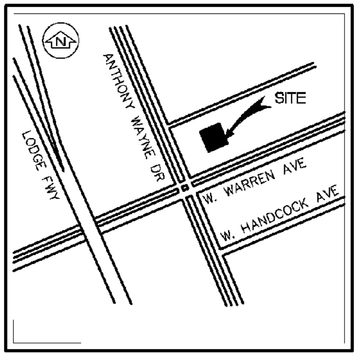
**Figure No. 2**



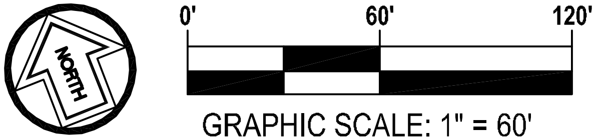


## LOCATION MAP

NTS

## LEGEND

⌖ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 60'

NOTE:
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Date 07-21-14
Drawn By GM
Designed By KLW
Scale 1" = 60'
Project 069961.00

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
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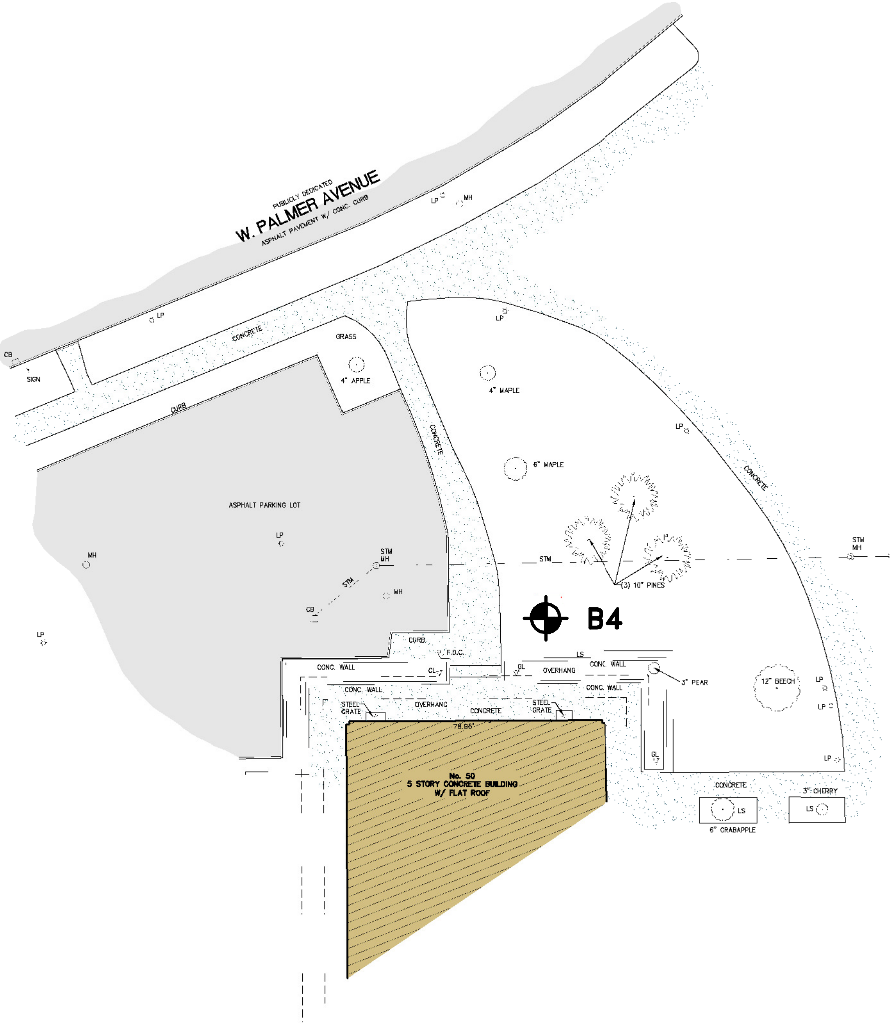
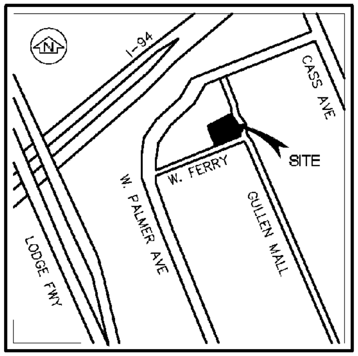
Figure No. 3



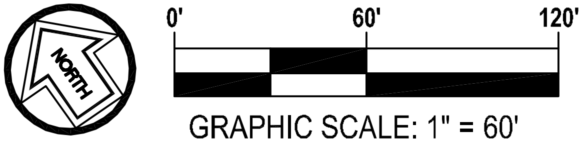


## LOCATION MAP

NTS

## LEGEND

⊕ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 60'

NOTE:
DRAWING INFORMATION TAKEN FROM SITE SURVEY (DATED 06-24-2014) PREPARED BY NOWAK & FRAUS ENGINEERS.

Jul 21, 2014 - 2:54pm - MANDRILA \\Smefile\work in progress\069961.00\CAD\DWGS\rev0\069961.00-04.dwg

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| | |
|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 60' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
|---|---|
| | |
| | |
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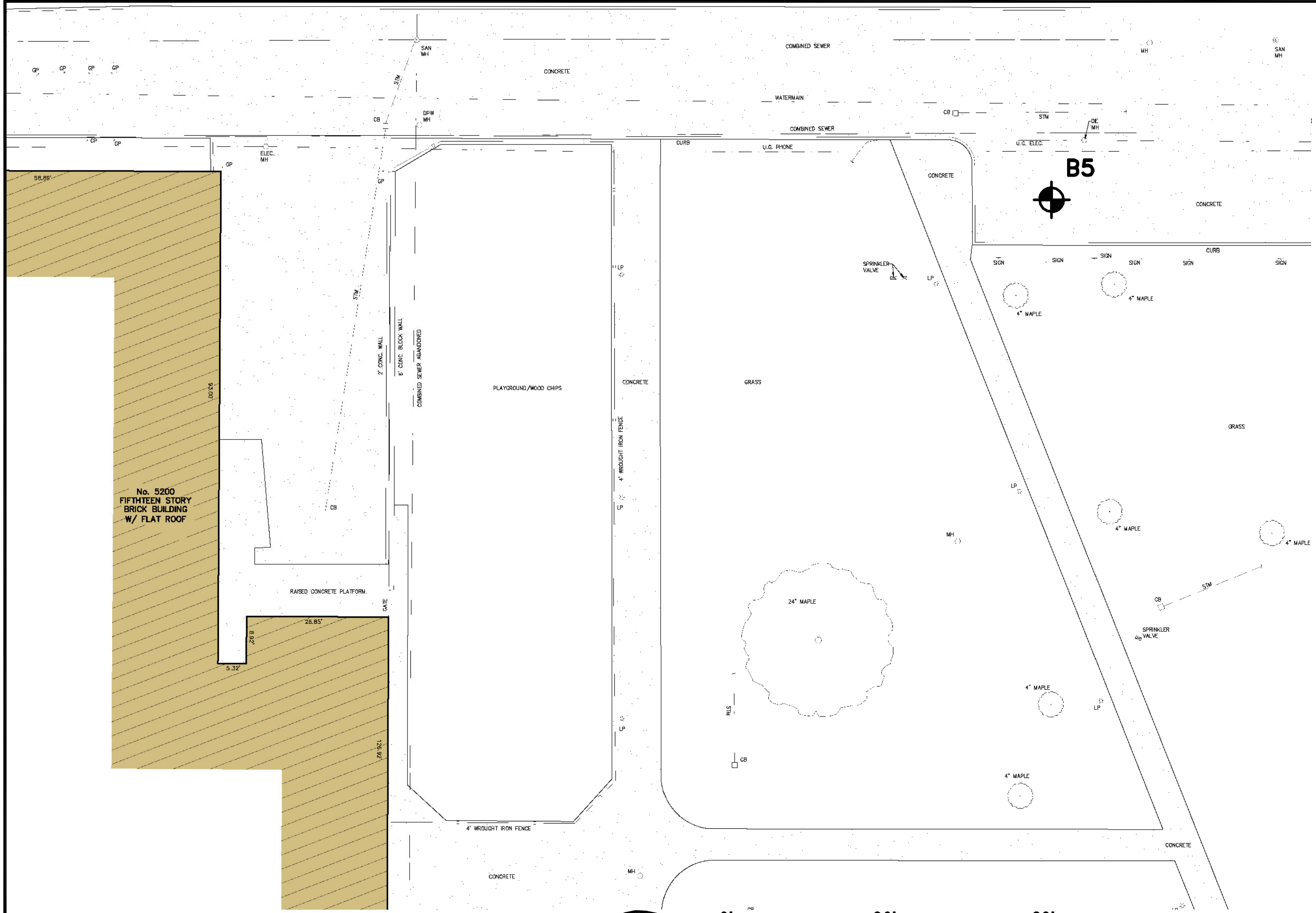
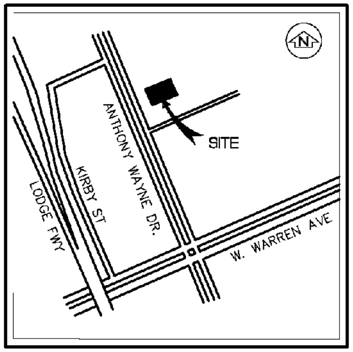
| | |

Figure No. 4



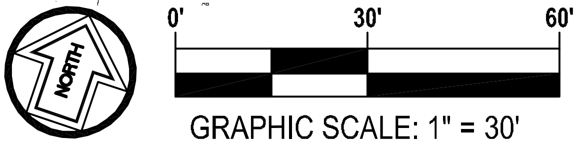


## LOCATION MAP

NTS

## LEGEND

⊕ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 30'

NOTE:
DRAWING INFORMATION TAKEN FROM SITE SURVEY (DATED 06–24–2014) PREPARED BY NOWAK & FRAUS ENGINEERS.

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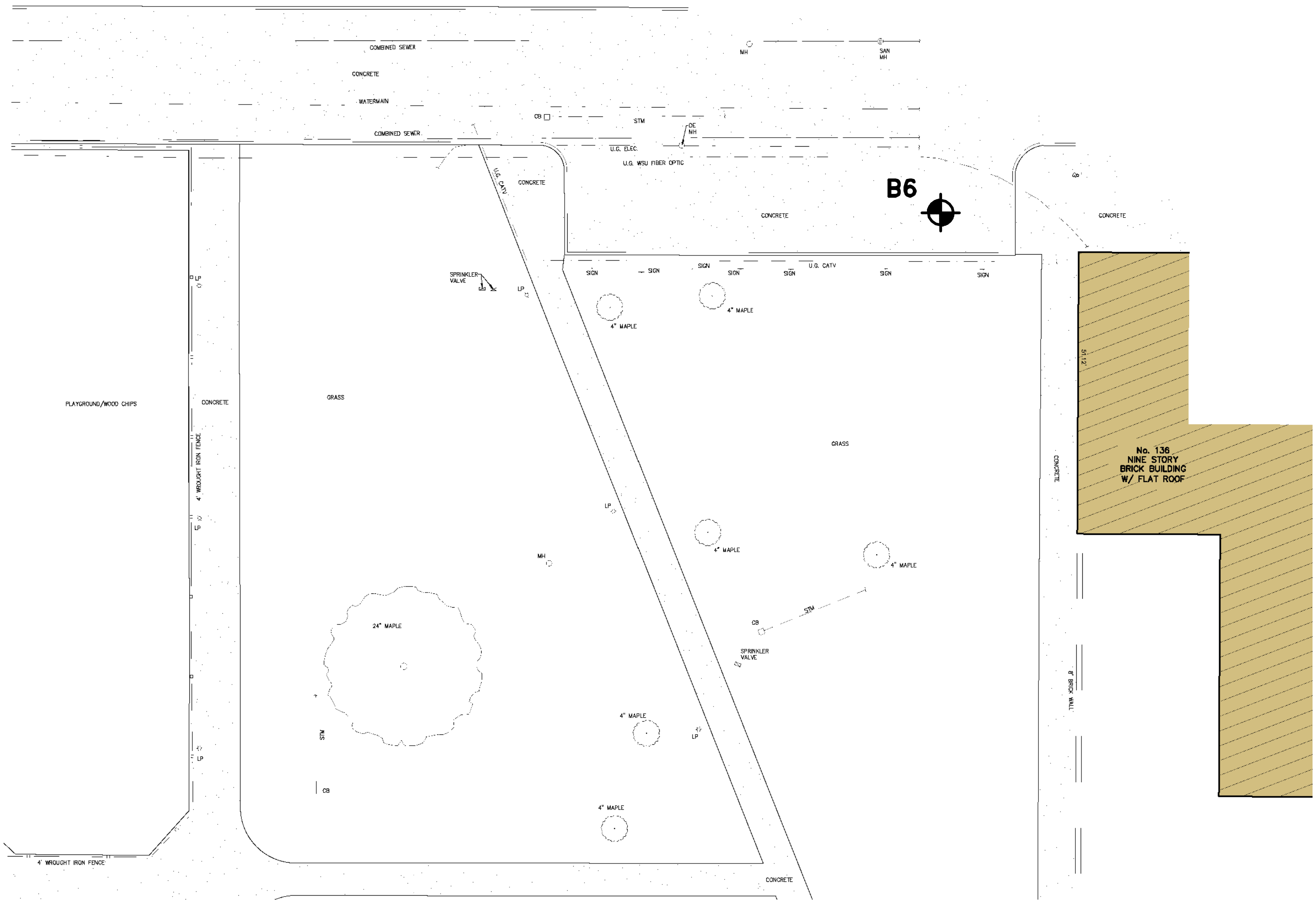
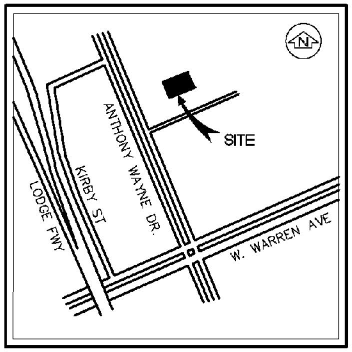
| | |
|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 30' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
|---|---|
| | |
| | |
| | |
| | |

Figure No. 5



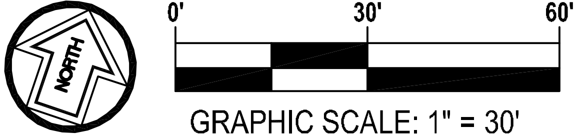


## LOCATION MAP

NTS

## LEGEND

⌖ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 30'

NOTE:
DRAWING INFORMATION TAKEN FROM SITE SURVEY (DATED 06-27-2014) PREPARED BY NOWAK & FRAUS ENGINEERS.

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| | |
|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 30' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
|---|---|
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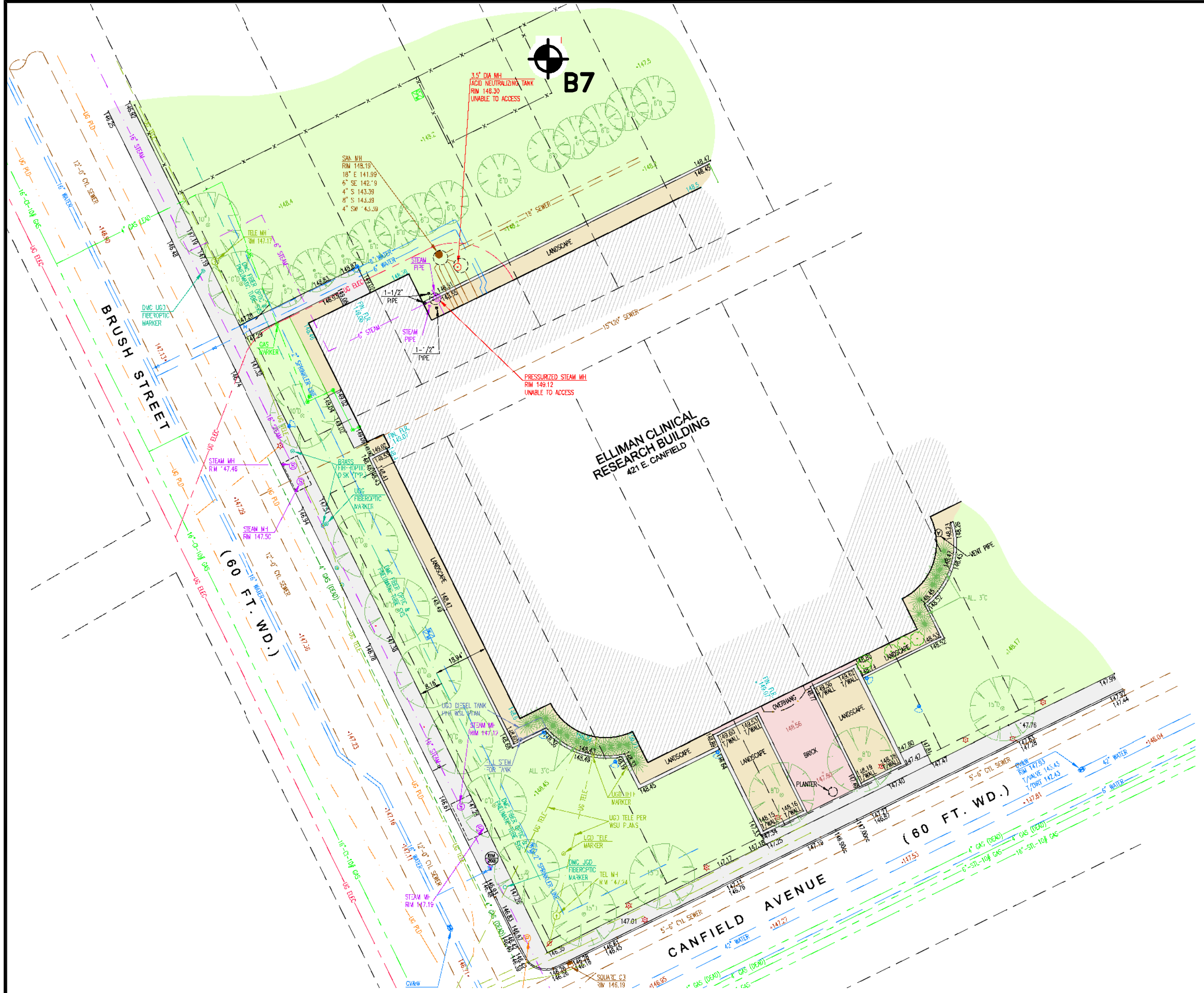
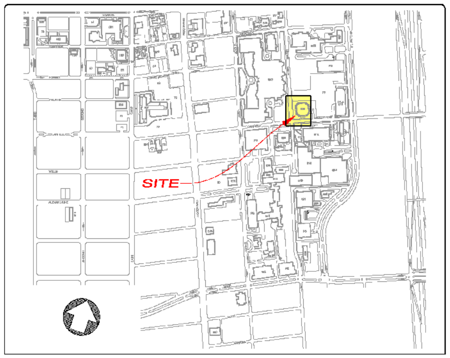
| | |
| | |

Figure No. 6



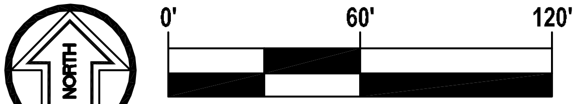


## LOCATION MAP

NTS

## LEGEND

⌖ APPROXIMATE BORING LOCATION



GRAPHIC SCALE: 1" = 60'

NOTE:
DRAWING INFORMATION TAKEN FROM TOPOGRAPHIC SURVEY (DATED 12–12–08) PREPARED BY METCO SERVICES.

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| | |
|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 60' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
|---|---|
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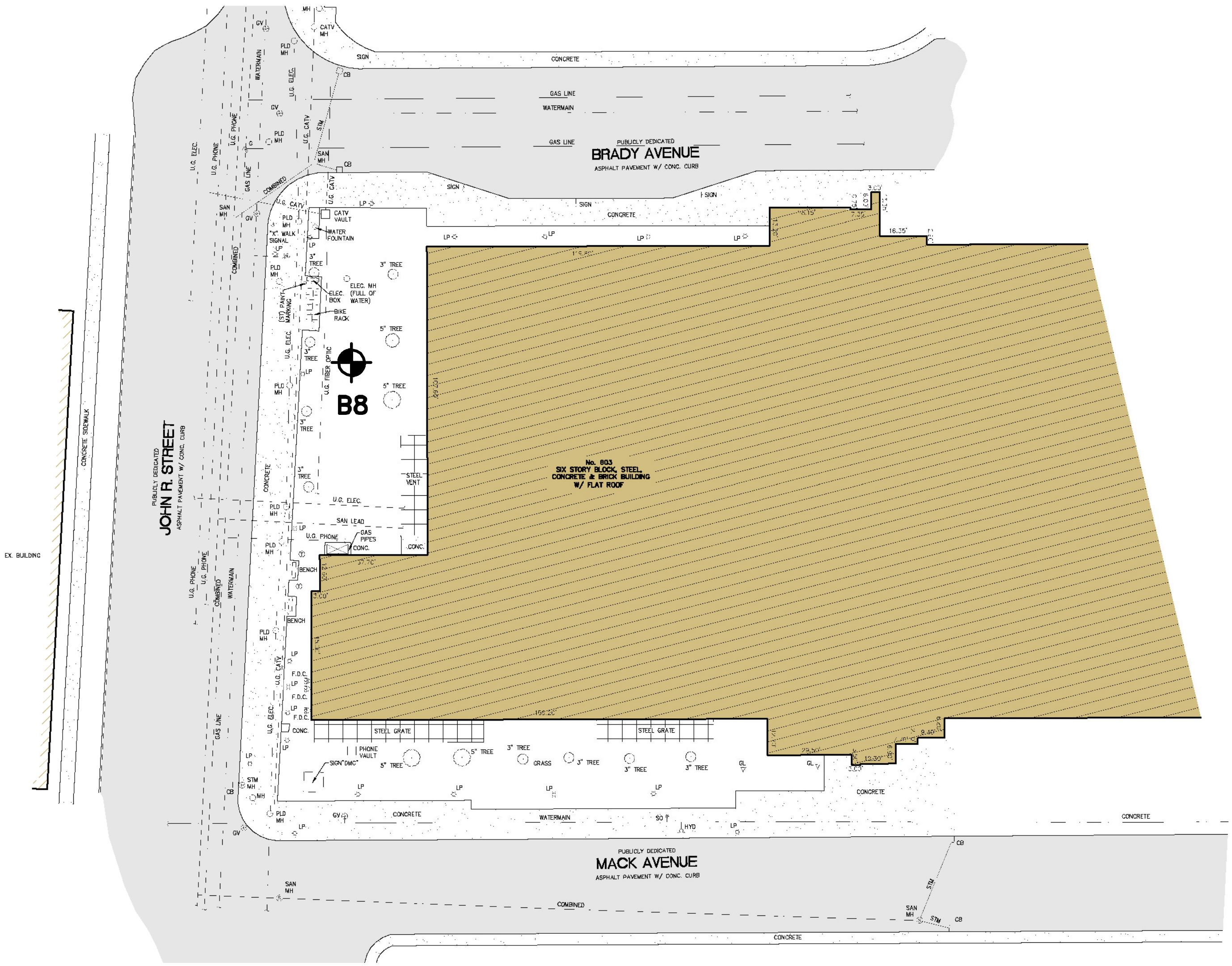
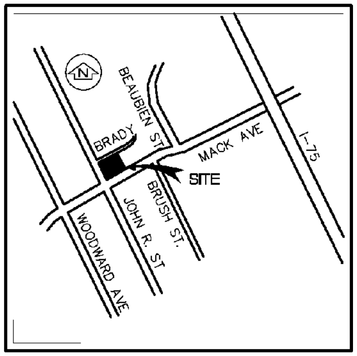
| | |
| | |

**Figure No. 7**





## LOCATION MAP

NTS

GRAPHIC SCALE: 1" = 60'

NOTE:
DRAWING INFORMATION TAKEN FROM SITE SURVEY (DATED 07–01–2014) PREPARED BY NOWAK & FRAUS ENGINEERS.

## LEGEND

⌖ APPROXIMATE BORING LOCATION

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| | |
|---|---|
| Date | 07-21-14 |
| Drawn By | GM |
| Designed By | KLW |
| Scale | 1" = 60' |
| Project | 069961.00 |

# BORING LOCATION DIAGRAM
# PROPOSED ELECTRICAL PADS
# WAYNE STATE UNIVERSITY
# DETROIT, MICHIGAN

| No. | Revision Date |
|---|---|
| | |
| | |
| | |
| | |

**Figure No. 8**

# BORING LOG TERMINOLOGY

## UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

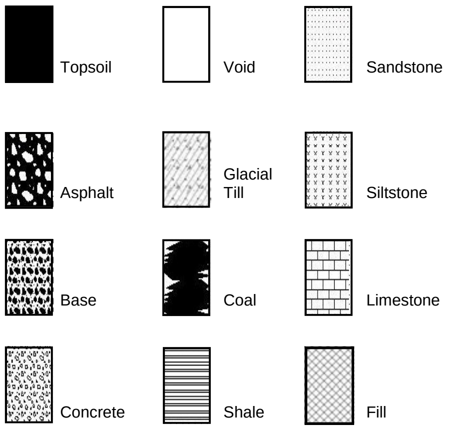
COARSE-GRAINED SOIL
(more than 50% of material is larger than No. 200 sieve size.)

| | | |
|---|---|---|
| | | Clean Gravel (Less than 5% fines) |
| **GRAVEL**<br>More than 50% of coarse fraction larger than No. 4 sieve size | GW | Well-graded gravel; gravel-sand mixtures, little or no fines |
| | GP | Poorly-graded gravel; gravel-sand mixtures, little or no fines |
| | | Gravel with fines (More than 12% fines) |
| | GM | Silty gravel; gravel-sand-silt mixtures |
| | GC | Clayey gravel; gravel-sand-clay mixtures |
| | | Clean Sand (Less than 5% fines) |
| **SAND**<br>50% or more of coarse fraction smaller than No. 4 sieve size | SW | Well-graded sand; sand-gravel mixtures, little or no fines |
| | SP | Poorly graded sand; sand-gravel mixtures, little or no fines |
| | | Sand with fines (More than 12% fines) |
| | SM | Silty sand; sand-silt-gravel mixtures |
| | SC | Clayey sand; sand–clay-gravel mixtures |

FINE-GRAINED SOIL
(50% or more of material is smaller than No. 200 sieve size)

| | | |
|---|---|---|
| **SILT AND CLAY**<br>Liquid limit less than 50% | ML | Inorganic silt; sandy silt or gravelly silt with slight plasticity |
| | CL | Inorganic clay of low plasticity; lean clay, sandy clay, gravelly clay |
| | OL | Organic silt and organic clay of low plasticity |
| **SILT AND CLAY**<br>Liquid limit 50% or greater | MH | Inorganic silt of high plasticity, elastic silt |
| | CH | Inorganic clay of high plasticity, fat clay |
| | OH | Organic silt and organic clay of high plasticity |
| **HIGHLY ORGANIC SOIL** | PT | Peat and other highly organic soil |

## OTHER MATERIAL SYMBOLS



## LABORATORY CLASSIFICATION CRITERIA

| | | |
|---|---|---|
| GW | $C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| GP | Not meeting all gradation requirements for GW | |
| GM | Atterberg limits below "A" line or PI less than 4 | Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols |
| GC | Atterberg limits above "A" line with PI greater than 7 | |
| SW | $C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| SP | Not meeting all gradation requirements for SW | |
| SM | Atterberg limits below "A" line or PI less than 4 | Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols |
| SC | Atterberg limits above "A" line with PI greater than 7 | |

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent……………………..……..GW, GP, SW, SP
More than 12 percent…………………..……..GM, GC, SM, SC
5 to 12 percent………………..……..Cases requiring dual symbols

- SP-SM or SW-SM (SAND with Silt or SAND with Silt and Gravel)
- SP-SC or SW-SC (SAND with Clay or SAND with Clay and Gravel)
- GP-GM or GW-GM (GRAVEL with Silt or GRAVEL with Silt and Sand)
- GP-GC or GW-GC (GRAVEL with Clay or GRAVEL with Clay and Sand)

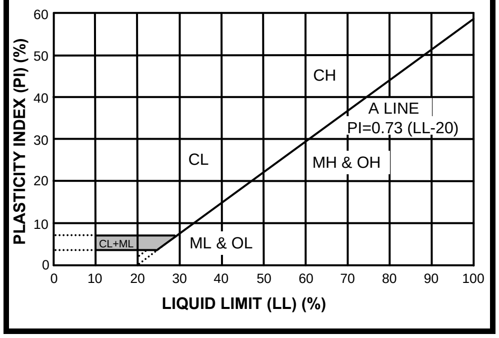
If the fines are CL-ML:

- SC-SM (SILTY CLAYEY SAND or SILTY CLAYEY SAND with Gravel)
- SM-SC (CLAYEY SILTY SAND or CLAYEY SILTY SAND with Gravel)
- GC-GM (SILTY CLAYEY GRAVEL or SILTY CLAYEY GRAVEL with Sand)
- GM-GC (CLAYEY SILTY GRAVEL or CLAYEY SILTY GRAVEL with Sand)

## PARTICLE SIZES

| | | |
|---|---|---|
| Boulders | - | Greater than 12 inches |
| Cobbles | - | 3 inches to 12 inches |
| Gravel- Coarse | - | 3/4 inches to 3 inches |
| Fine | - | No. 4 to 3/4 inches |
| Sand- Coarse | - | No. 10 to No. 4 |
| Medium | - | No. 40 to No. 10 |
| Fine | - | No. 200 to No. 40 |
| Silt and Clay | - | Less than (0.0074 mm) |

## PLASTICITY CHART



## VISUAL MANUAL PROCEDURE

When laboratory tests are not performed to confirm the classification of soils exhibiting borderline classifications, the two possible classifications would be separated with a slash, as follows:

For soils where it is difficult to distinguish if it is a coarse or fine-grained soil:

- SC/CL (CLAYEY SAND to Sandy LEAN CLAY)
- SM/ML (SILTY SAND to Sandy SILT)
- GC/CL (CLAYEY GRAVEL to Gravelly LEAN CLAY)
- GM/ML (SILTY GRAVEL to Gravelly SILT)

For soils where it is difficult to distinguish if it is sand or gravel, poorly or well-graded sand or gravel; silt or clay; or plastic or non-plastic silt or clay:

- SP/GP or SW/GW (SAND with Gravel to GRAVEL with Sand)
- SC/GC (CLAYEY SAND with Gravel to CLAYEY GRAVEL with Sand)
- SM/GM (SILTY SAND with Gravel to SILTY GRAVEL with Sand)
- SW/SP (SAND or SAND with Gravel)
- GP/GW (GRAVEL or GRAVEL with Sand)
- SC/SM (CLAYEY to SILTY SAND)
- GM/GC (SILTY to CLAYEY GRAVEL)
- CL/ML (SILTY CLAY)
- ML/CL (CLAYEY SILT)
- CH/MH (FAT CLAY to ELASTIC SILT)
- CL/CH (LEAN to FAT CLAY)
- MH/ML (ELASTIC SILT to SILT)
- OL/OH (ORGANIC SILT or ORGANIC CLAY)

## DRILLING AND SAMPLING ABBREVIATIONS

| | | |
|---|---|---|
| 2ST | – | Shelby Tube – 2" O.D. |
| 3ST | – | Shelby Tube – 3" O.D. |
| AS | – | Auger Sample |
| GS | – | Grab Sample |
| LS | – | Liner Sample |
| NR | – | No Recovery |
| PM | – | Pressure Meter |
| RC | – | Rock Core diamond bit. NX size, except where noted |
| SB | – | Split Barrel Sample 1-3/8" I.D., 2" O.D., except where noted |
| VS | – | Vane Shear |
| WS | – | Wash Sample |

## OTHER ABBREVIATIONS

| | | |
|---|---|---|
| WOH | – | Weight of Hammer |
| WOR | – | Weight of Rods |
| SP | – | Soil Probe |
| PID | – | Photo Ionization Device |
| FID | – | Flame Ionization Device |

## DEPOSITIONAL FEATURES

| | | |
|---|---|---|
| Parting | – | as much as 1/16 inch thick |
| Seam | – | 1/16 inch to 1/2 inch thick |
| Layer | – | 1/2 inch to 12 inches thick |
| Stratum | – | greater than 12 inches thick |
| Pocket | – | deposit of limited lateral extent |
| Lens | – | lenticular deposit |
| Hardpan/Till | – | an unstratified, consolidated or cemented mixture of clay, silt, sand and/or gravel, the size/shape of the constituents vary widely |
| Lacustrine | – | soil deposited by lake water |
| Mottled | – | soil irregularly marked with spots of different colors that vary in number and size |
| Varved | – | alternating partings or seams of silt and/or clay |
| Occasional | – | one or less per foot of thickness |
| Frequent | – | more than one per foot of thickness |
| Interbedded | – | strata of soil or beds of rock lying between or alternating with other strata of a different nature |

## CLASSIFICATION TERMINOLOGY AND CORRELATIONS

**Cohesionless Soils**

| **Relative Density** | **N-Value (Blows per foot)** |
|---|---|
| Very Loose | 0 to 4 |
| Loose | 4 to 10 |
| Medium Dense | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | 50 to 80 |
| Extremely Dense | Over 80 |

**Cohesive Soils**

| **Consistency** | **N-Value (Blows per foot)** | **Undrained Shear Strength (kips/ft$^2$)** |
|---|---|---|
| Very Soft | 0 - 2 | 0.25 or less |
| Soft | 2 - 4 | 0.25 to 0.50 |
| Medium | 4 - 8 | 0.50 to 1.0 |
| Stiff | 8 - 15 | 1.0 to 2.0 |
| Very Stiff | 15 - 30 | 2.0 to 4.0 |
| Hard | > 30 | 4.0 or greater |

Standard Penetration 'N-Value' = Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split barrel sampler, except where noted.

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**michigan, ohio and indiana**

# BORING B 1

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/10/14
**COMPLETED:** 7/10/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** JB
**RIG NO.:** 281
**LOGGED BY:** SEB
**CHECKED BY:** KLW

| DEPTH (FEET) | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE -- ○ | MOISTURE & ATTERBERG LIMITS (%) | SHEAR STRENGTH (KSF) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.2 | 2 inches of TOPSOIL | | | | | | | |
| 3.5 | FILL- Fine to Medium SAND with Silt- Trace Brick Fragments- Dark Brown- Moist- Loose (SP-SM) | SB1 | 16 | 3<br>4<br>5 | 9 | | | Organic content = 2.7% |
| 6.0 | FILL- Sandy LEAN CLAY- Brown- Hard (CL) | SB2 | 16 | 3<br>6<br>8 | 14 | 11 | 4.5+ | |
| 13.0 | LEAN CLAY with Sand- Frequent Silt Partings- Brown- Hard (CL) | SB3 | 16 | 4<br>5<br>9 | 14 | 11 | 4.5+ | |
| | | SB4 | 16 | 14<br>18<br>23 | 41 | 14 | 4.5+ | |
| 15.0 | LEAN CLAY with Sand- Gray- Hard (CL) | SB5 | 16 | 5<br>7<br>10 | 17 | 12 | ▽ | |
| | END OF BORING AT 15.0 FEET. | | | | | | | |

DRY DENSITY (pcf) -- ■ 90 100 110 120

MOISTURE & ATTERBERG LIMITS (%) PL MC LL 10 20 30 40

▽ HAND PENE.
☒ TORVANE SHEAR
○ UNC.COMP.
⊡ VANE SHEAR (PK)
× VANE SHEAR (REM)
⊕ TRIAXIAL (UU)

**GROUNDWATER & BACKFILL INFORMATION**

| | DEPTH (FT) |
|---|---|
| ▽ **DURING BORING:** | 3.0 |
| ▼ **AT END OF BORING:** | 14.0 |

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

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**michigan, ohio and indiana**

# BORING B 2

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads

**PROJECT NUMBER:** 069961.00

**CLIENT:** Wayne State University

**PROJECT LOCATION:** Detroit, Michigan

**DATE STARTED:** 7/9/14

**COMPLETED:** 7/9/14

**BORING METHOD:** Solid-stem Augers

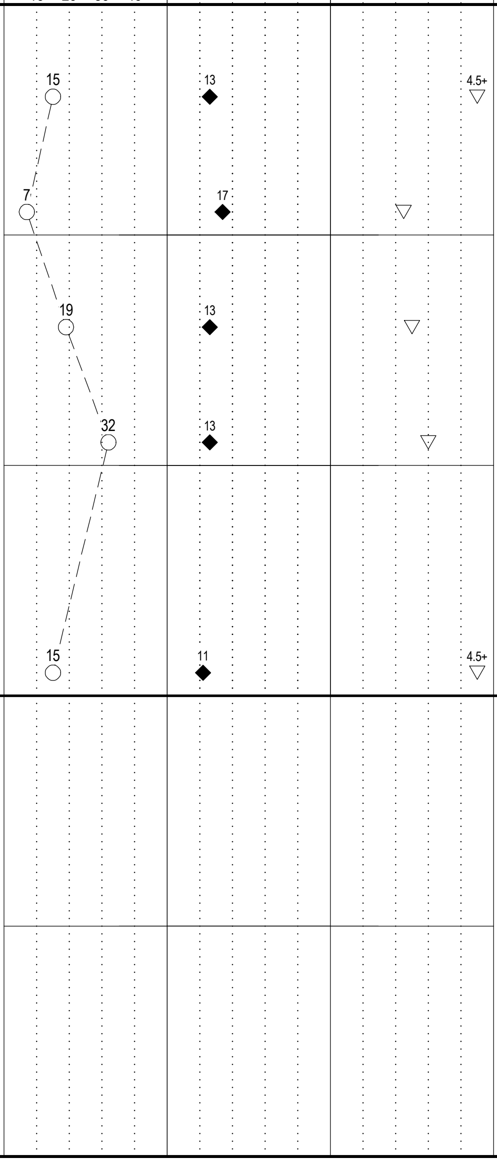
**DRILLER:** RM

**RIG NO.:** 167

**LOGGED BY:** SEB

**CHECKED BY:** KLW

| DEPTH (FEET) | SYMBOLIC PROFILE | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE -- ○ | DRY DENSITY (pcf) -- ■ / MOISTURE & ATTERBERG LIMITS (%) PL MC LL | ▽ HAND PENE. ☒ TORVANE SHEAR ○ UNC.COMP. ⊡ VANE SHEAR (PK) × VANE SHEAR (REM) ⊕ TRIAXIAL (UU) SHEAR STRENGTH (KSF) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.4 | 5 inches of Portland Cement CONCRETE | | | | | | | |
| | | FILL- LEAN CLAY with Sand- Trace Brick Fragments- Occasional Topsoil Layers- Brown- Hard to Very Stiff (CL) | SB1 | 18 | 6<br>8<br>7 | 15 | 13 | 4.5+ | |
| | | | SB2 | 18 | 3<br>3<br>4 | 7 | 17 | | |
| 5 | 6.0 | | | | | | | | |
| | | LEAN CLAY- Frequent Silt Partings- Brown & Gray- Very Stiff (CL) | SB3 | 18 | 5<br>7<br>12 | 19 | 13 | | |
| 10 | | | SB4 | 18 | 12<br>15<br>17 | 32 | 13 | | |
| | 12.0 | LEAN CLAY with Sand- Gray- Hard (CL) | SB5 | 18 | 5<br>7<br>8 | 15 | 11 | 4.5+ | |
| 15 | 15.0 | END OF BORING AT 15.0 FEET. | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |



**GROUNDWATER & BACKFILL INFORMATION**

GROUNDWATER WAS NOT ENCOUNTERED

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

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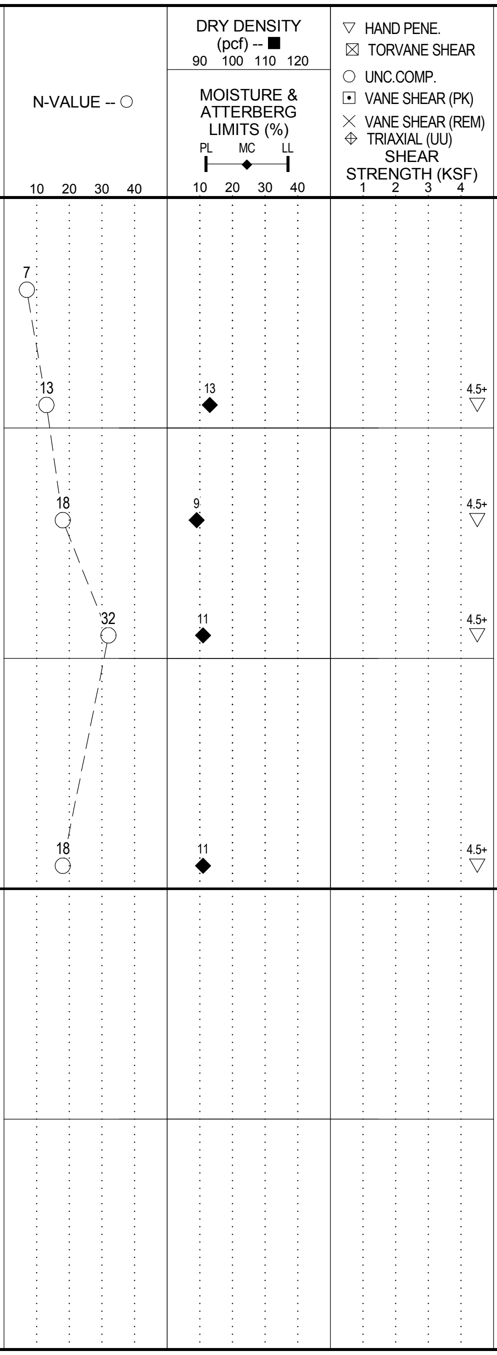
# BORING B 3

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/9/14
**COMPLETED:** 7/9/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** RM
**RIG NO.:** 167
**LOGGED BY:** SEB
**CHECKED BY:** KLW

| SYMBOLIC PROFILE | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE -- ○ | MOISTURE & ATTERBERG LIMITS (%) | SHEAR STRENGTH (KSF) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.4 | 5 inches of Portland Cement CONCRETE | | | | | | | |
| 3.5 | FILL- Fine to Medium SAND with Silt- Occasional Topsoil Layers- Brown- Moist- Loose (SP-SM) | SB1 | 18 | 3<br>3<br>4 | 7 | | | |
| 11.0 | LEAN CLAY with Sand- Occasional Silt Partings- Brown & Gray- Hard (CL) | SB2 | 18 | 5<br>6<br>7 | 13 | 13 | 4.5+ | |
| | | SB3 | 18 | 6<br>8<br>10 | 18 | 9 | 4.5+ | |
| | | SB4 | 18 | 10<br>15<br>17 | 32 | 11 | 4.5+ | |
| 15.0 | LEAN CLAY with Sand- Gray- Hard (CL) | SB5 | 18 | 6<br>7<br>11 | 18 | 11 | 4.5+ | |

END OF BORING AT 15.0 FEET.



DEPTH (FEET): 0, 5, 10, 15, 20, 25

**GROUNDWATER & BACKFILL INFORMATION**

GROUNDWATER WAS NOT ENCOUNTERED

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

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# BORING B 4

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads

**PROJECT NUMBER:** 069961.00

**CLIENT:** Wayne State University

**PROJECT LOCATION:** Detroit, Michigan

**DATE STARTED:** 7/9/14

**COMPLETED:** 7/9/14

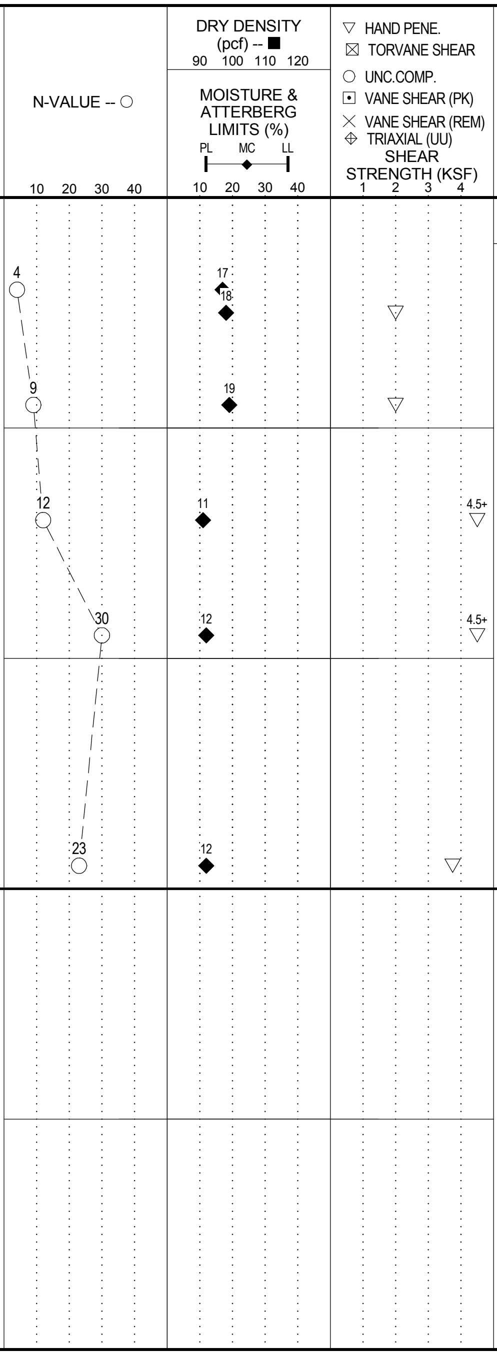
**BORING METHOD:** Solid-stem Augers

**DRILLER:** RM

**RIG NO.:** 167

**LOGGED BY:** SEB

**CHECKED BY:** KLW



| DEPTH (FEET) | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE | MOISTURE (%) | SHEAR STRENGTH (KSF) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0 – 2.0 | TOPSOIL- Fine to Medium CLAYEY SAND- Black- Moist- Very Loose (SC) | SB1 | 18 | 1<br>2<br>2 | 4 | 17<br>18 |  | Organic content = 4.0% |
| 2.0 – 6.0 | FILL- LEAN CLAY with Sand- Trace Brick Fragments- Occasional Topsoil Layers- Brown & Gray- Very Stiff (CL) | SB2 | 18 | 3<br>4<br>5 | 9 | 19 |  |  |
| 6.0 – 11.8 | LEAN CLAY with Sand- Occasional Silt Partings- Brown & Gray- Hard (CL) | SB3 | 18 | 5<br>5<br>7 | 12 | 11 | 4.5+ |  |
|  |  | SB4 | 18 | 12<br>15<br>15 | 30 | 12 | 4.5+ |  |
| 11.8 – 15.0 | LEAN CLAY with Sand- Gray- Hard (CL) | SB5 | 18 | 10<br>10<br>13 | 23 | 12 |  |  |
| 15.0 | END OF BORING AT 15.0 FEET. |  |  |  |  |  |  |  |

**GROUNDWATER & BACKFILL INFORMATION**

GROUNDWATER WAS NOT ENCOUNTERED

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

**soil and materials engineers, inc.**
**michigan, ohio and indiana**

# BORING B 5

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/9/14
**COMPLETED:** 7/9/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** RM
**RIG NO.:** 167
**LOGGED BY:** SEB
**CHECKED BY:** KLW

| DEPTH (FEET) | SYMBOLIC PROFILE | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE -- ○<br>10 20 30 40 | DRY DENSITY (pcf) -- ■<br>90 100 110 120<br>MOISTURE & ATTERBERG LIMITS (%)<br>PL MC LL<br>10 20 30 40 | ▽ HAND PENE.<br>☒ TORVANE SHEAR<br>○ UNC.COMP.<br>⊡ VANE SHEAR (PK)<br>× VANE SHEAR (REM)<br>⊕ TRIAXIAL (UU)<br>SHEAR STRENGTH (KSF)<br>1 2 3 4 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.5 | 6 inches of Portland Cement CONCRETE | | | | | | | |
| | | FILL- Fine to Medium SAND with Silt- Brown- Moist to Wet- Medium Dense (SP-SM) | SB1 | 18 | 6<br>7<br>9 | 16 | | | |
| | | | SB2 | 18 | 5<br>5<br>6 | 11 | | | |
| 5<br>▽ | 5.5 | | | | | | | | |
| | | LEAN CLAY with Sand- Occasional Silt Partings- Brown & Gray- Hard (CL) | SB3 | 18 | 6<br>9<br>12 | 21 | ◆ 11 | ▽ 4.5+ | |
| 10 | | | SB4 | 18 | 8<br>12<br>14 | 26 | ◆ 15 | ▽ 4.5+ | |
| | 11.5 | | | | | | | | |
| | | LEAN CLAY with Sand- Gray- Hard (CL) | SB5 | 18 | 5<br>6<br>8 | 14 | ◆ 17 | ▽ | |
| 15 | 15.0 | END OF BORING AT 15.0 FEET. | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |

**GROUNDWATER & BACKFILL INFORMATION**

| | DEPTH (FT) |
|---|---|
| ▽ **DURING BORING:** | 5.5 |
| ▼ **AT END OF BORING:** | None |

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

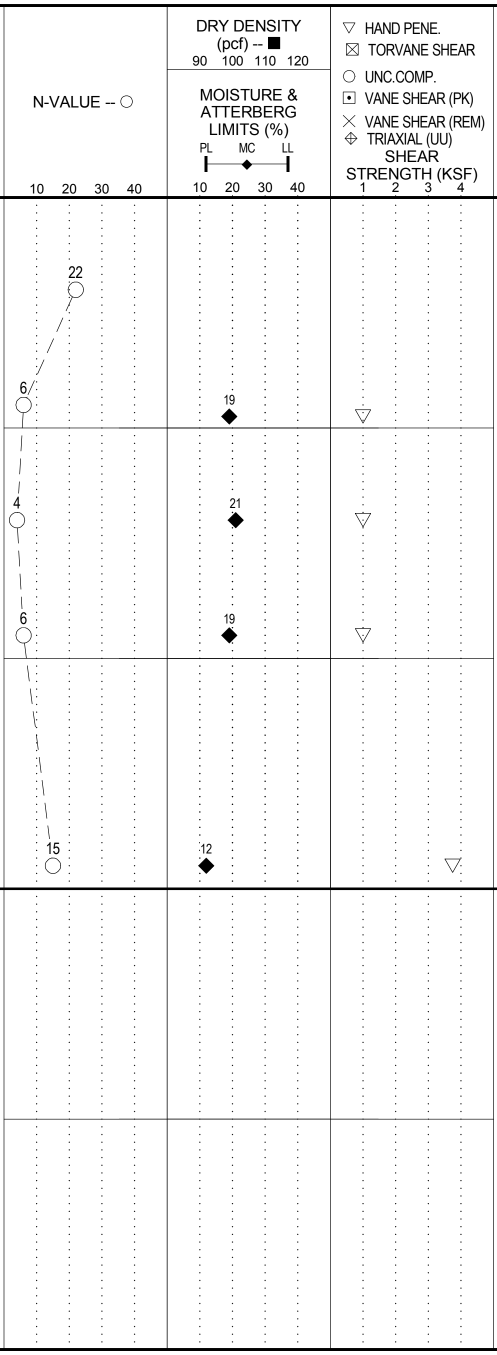
# BORING B 6

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/9/14
**COMPLETED:** 7/9/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** RM
**RIG NO.:** 167
**LOGGED BY:** SEB
**CHECKED BY:** KLW

| DEPTH (FEET) | PROFILE DESCRIPTION |
|---|---|
| 0.5 | 6 inches of Portland Cement CONCRETE |
| 4.5 | FILL- Fine to Medium SAND with Silt- Brown- Moist- Medium Dense to Loose (SP-SM) |
| 11.8 | FILL- LEAN CLAY with Sand- Occasional Topsoil Partings- Brown & Gray- Stiff (CL) |
| 15.0 | LEAN CLAY with Sand- Gray- Very Stiff (CL) |
| | END OF BORING AT 15.0 FEET. |

| SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | REMARKS |
|---|---|---|---|
| SB1 | 18 | 8<br>10<br>12 | |
| SB2 | 18 | 4<br>3<br>3 | |
| SB3 | 18 | 2<br>2<br>2 | |
| SB4 | 18 | 2<br>2<br>4 | |
| SB5 | 18 | 6<br>7<br>8 | |



**GROUNDWATER & BACKFILL INFORMATION**

GROUNDWATER WAS NOT ENCOUNTERED

**BACKFILL METHOD:** Auger Cuttings

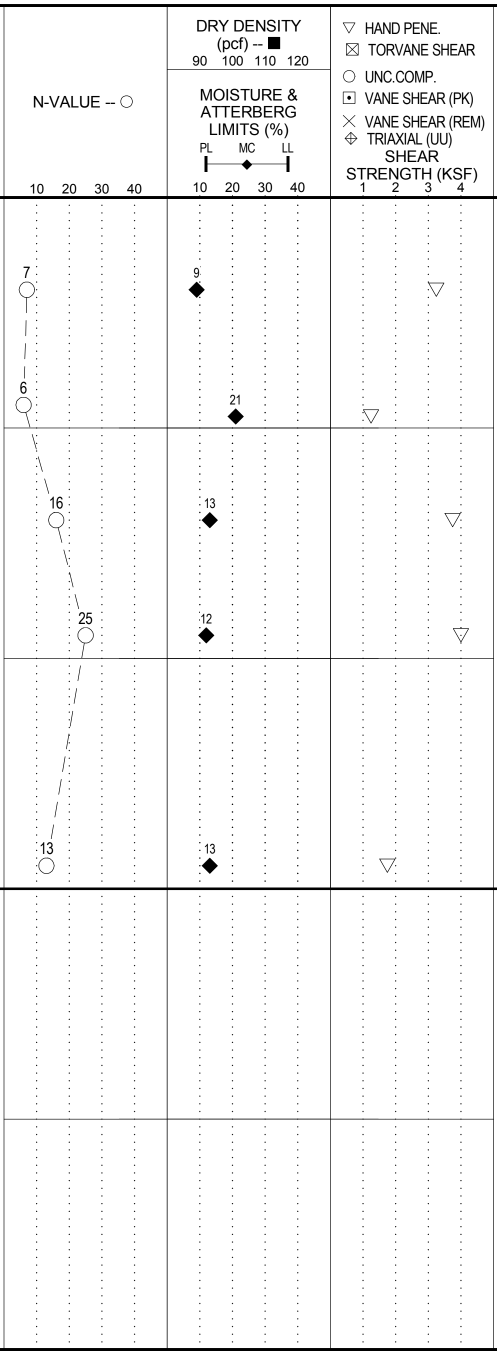
NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

# BORING B 7

PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/9/14
**COMPLETED:** 7/9/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** RM
**RIG NO.:** 167
**LOGGED BY:** SEB
**CHECKED BY:** KLW

| DEPTH (FEET) | SYMBOLIC PROFILE | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | REMARKS |
|---|---|---|---|---|---|---|
| 0 | 0.5 | 6 inches of Clayey TOPSOIL- Black | | | | |
| ▽ | 3.0 | FILL- Sandy LEAN CLAY- Trace Brick & Cinder Fragments- Brown & Dark Brown- Very Stiff (CL) | SB1 | 18 | 3<br>3<br>4 | |
| | 4.5 | Fine to Medium SILTY SAND- Brown & Gray- Wet- Very Loose (SM) | SB2 | 18 | 2<br>2<br>4 | |
| 5 | 6.0 | LEAN CLAY with Sand- Brown & Gray- Stiff (CL) | | | | |
| 10<br>▼<br>15 | 15.0 | LEAN CLAY with Sand- Gray- Very Stiff to Stiff (CL) | SB3<br>SB4<br>SB5 | 18<br>18<br>18 | 6<br>7<br>9<br>10<br>12<br>13<br>5<br>6<br>7 | |
| 20<br>25 | | END OF BORING AT 15.0 FEET. | | | | |



| GROUNDWATER & BACKFILL INFORMATION | DEPTH (FT) |
|---|---|
| ▽ **DURING BORING:** | 3.0 |
| ▼ **AT END OF BORING:** | 13.0 |

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

# BORING B 8

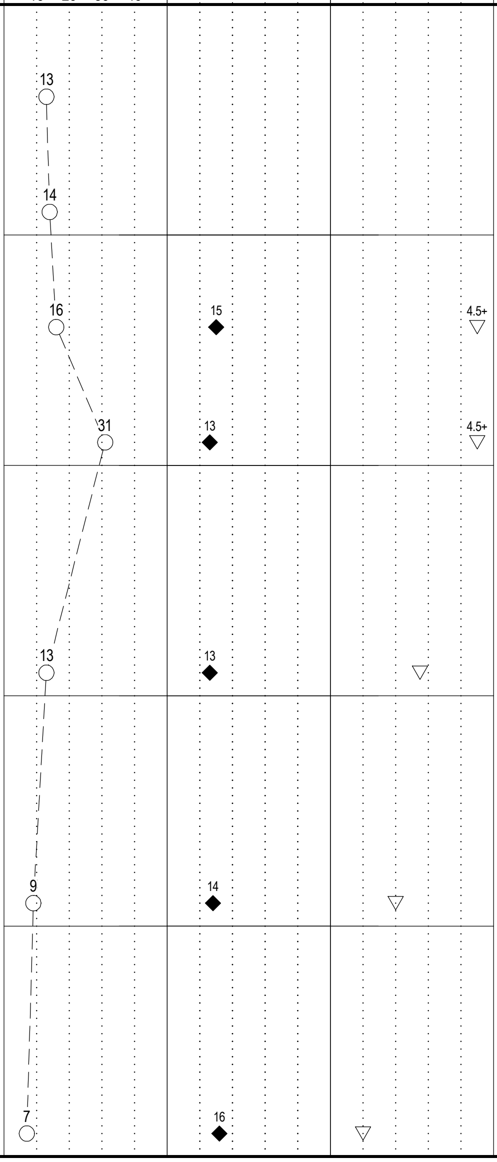
PAGE 1 OF 1

**PROJECT NAME:** Wayne State University Electrical Pads
**PROJECT NUMBER:** 069961.00
**CLIENT:** Wayne State University
**PROJECT LOCATION:** Detroit, Michigan
**DATE STARTED:** 7/10/14
**COMPLETED:** 7/10/14
**BORING METHOD:** Solid-stem Augers
**DRILLER:** JB
**RIG NO.:** 281
**LOGGED BY:** SEB
**CHECKED BY:** KLW

DRY DENSITY (pcf) -- ■ 90 100 110 120

▽ HAND PENE.
☒ TORVANE SHEAR
○ UNC.COMP.
⊡ VANE SHEAR (PK)
× VANE SHEAR (REM)
⊕ TRIAXIAL (UU)

| DEPTH (FEET) | PROFILE DESCRIPTION | SAMPLE TYPE/NO. INTERVAL | RECOVERY LENGTH (INCHES) | BLOWS PER SIX INCHES | N-VALUE -- ○ | MOISTURE & ATTERBERG LIMITS (%) PL MC LL | SHEAR STRENGTH (KSF) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.1 | 1 inch of TOPSOIL | | | | | | | |
| 6.5 | FILL- Fine to Medium SAND with Silt- Brown- Moist- Medium Dense (SP-SM) | SB1 | 16 | 4<br>6<br>7 | 13 | | | |
| | | SB2 | 16 | 4<br>7<br>7 | 14 | | | |
| 11.0 | LEAN CLAY with Sand- Frequent Silt Partings- Brown- Hard (CL) | SB3 | 16 | 3<br>5<br>11 | 16 | 15 | 4.5+ ▽ | |
| | | SB4 | 16 | 8<br>14<br>17 | 31 | 13 | 4.5+ ▽ | |
| 25.0 | LEAN CLAY with Sand- Gray- Very Stiff to Stiff (CL) | SB5 | 16 | 4<br>5<br>8 | 13 | 13 | ▽ | |
| | | SB6 | 16 | 2<br>4<br>5 | 9 | 14 | ▽ | |
| | | SB7 | 16 | 2<br>3<br>4 | 7 | 16 | ▽ | |



END OF BORING AT 25.0 FEET.

**GROUNDWATER & BACKFILL INFORMATION**

GROUNDWATER WAS NOT ENCOUNTERED

**BACKFILL METHOD:** Auger Cuttings

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

# Important Information About Your

# Geotechnical Engineering Report

*Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.*

*The following information is provided to help you manage your risks.*

## Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

## Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

## A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

## Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

## Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

## A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

## A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

## Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

## Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

## Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

## Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

## Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

## Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

# GENERAL COMMENTS

## Basis of Geotechnical Report

This report has been prepared in accordance with generally accepted geotechnical engineering practices to assist in the design and/or evaluation of this project. If the project plans, design criteria, and other project information referenced in this report and utilized by SME to prepare our recommendations are changed, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions and recommendations of this report are modified or approved in writing by our office.

The discussions and recommendations submitted in this report are based on the available project information, described in this report, and the geotechnical data obtained from the field exploration at the locations indicated in the report. Variations in the soil and groundwater conditions commonly occur between or away from sampling locations. The nature and extent of the variations may not become evident until the time of construction. If significant variations are observed during construction, SME should be contacted to reevaluate the recommendations of this report. SME should be retained to continue our services through construction to observe and evaluate the actual subsurface conditions relative to the recommendations made in this report.

In the process of obtaining and testing samples and preparing this report, procedures are followed that represent reasonable and accepted practice in the field of soil and foundation engineering. Specifically, field logs are prepared during the field exploration that describe field occurrences, sampling locations, and other information. Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory and differences may exist between the field logs and the report logs. The engineer preparing the report reviews the field logs, laboratory classifications, and test data and then prepares the report logs. Our recommendations are based on the contents of the report logs and the information contained therein.

## Review of Design Details, Plans, and Specifications

SME should be retained to review the design details, project plans, and specifications to verify those documents are consistent with the recommendations contained in this report.

## Review of Report Information With Project Team

Implementation of our recommendations may affect the design, construction, and performance of the proposed improvements, along with the potential inherent risks involved with the proposed construction. The client and key members of the design team, including SME, should discuss the issues covered in this report so that the issues are understood and applied in a manner consistent with the owner's budget, tolerance of risk, and expectations for performance and maintenance.

## Field Verification of Geotechnical Conditions

SME should be retained to verify the recommendations of this report are properly implemented during construction. This may avoid misinterpretation of our recommendations by other parties and will allow us to review and modify our recommendations if variations in the site subsurface conditions are encountered.

## Project Information for Contractor

This report and any future addenda or other reports regarding this site should be made available to prospective contractors prior to submitting their proposals for their information only and to supply them with facts relative to the subsurface evaluation and laboratory test results. If the selected contractor encounters subsurface conditions during construction, which differ from those presented in this report, the contractor should promptly describe the nature and extent of the differing conditions in writing and SME should be notified so that we can verify those conditions. The construction contract should include provisions for dealing with differing conditions and contingency funds should be reserved for potential problems during earthwork and foundation construction. We would be pleased to assist you in developing the contract provisions based on our experience.

The contractor should be prepared to handle environmental conditions encountered at this site, which may affect the excavation, removal, or disposal of soil; dewatering of excavations; and health and safety of workers. Any Environmental Assessment reports prepared for this site should be made available for review by bidders and the successful contractor.

## Third Party Reliance/Reuse of This Report

This report has been prepared solely for the use of our Client for the project specifically described in this report. This report cannot be relied upon by other parties not involved in the project, unless specifically allowed by SME in writing. SME also is not responsible for the interpretation by other parties of the geotechnical data and the recommendations provided herein.

# LABORATORY TESTING PROCEDURES

## Visual Engineering Classification

Visual classification was performed on recovered samples. The appended General Notes and Unified Soil Classification System (USCS) sheets include a brief summary of the general method used visually classify the soil and assign an appropriate USCS group symbol. The estimated group symbol, according to the USCS, is shown in parentheses following the textural description of the various strata on the boring logs appended to this report. The soil descriptions developed from visual classifications are sometimes modified to reflect the results of laboratory testing.

## Moisture Content

Moisture content tests were performed by weighing samples from the field at their in-situ moisture condition. These samples were then dried at a constant temperature (approximately 110º C) overnight in an oven. After drying, the samples were weighed to determine the dry weight of the sample and the weight of the water that was expelled during drying. The moisture content of the specimen is expressed as a percent and is the weight of the water compared to the dry weight of the specimen.

## Hand Penetrometer Tests

In the hand penetrometer test, the unconfined compressive strength of a cohesive soil sample is estimated by measuring the resistance of the sample to the penetration of a small calibrated, spring-loaded cylinder. The maximum capacity of the penetrometer is 4.5 tons per square-foot (tsf). Theoretically, the undrained shear strength of the cohesive sample is one-half the unconfined compressive strength. The undrained shear strength (based on the hand penetrometer test) presented on the boring logs is reported in units of kips per square-foot (ksf).

## Torvane Shear Tests

In the Torvane test, the shear strength of a low strength, cohesive soil sample is estimated by measuring the resistance of the sample to a torque applied through vanes inserted into the sample. The undrained shear strength of the samples is measured from the maximum torque required to shear the sample and is reported in units of kips per square-foot (ksf).

## Loss-on-Ignition (Organic Content) Tests

Loss-on-ignition (LOI) tests are conducted by first weighing the sample and then heating the sample to dry the moisture from the sample (in the same manner as determining the moisture content of the soil). The sample is then re-weighed to determine the dry weight and then heated for 4 hours in a muffle furnace at a high temperature (approximately 440º C). After cooling, the sample is re-weighed to calculate the amount of ash remaining, which in turn is used to determine the amount of organic matter burned from the original dry sample. The organic matter content of the specimen is expressed as a percent compared to the dry weight of the sample.

## Atterberg Limits Tests

Atterberg limits tests consist of two components. The plastic limit of a cohesive sample is determined by rolling the sample into a thread and the plastic limit is the moisture content where a 1/8-inch thread begins to crumble. The liquid limit is determined by placing a ½-inch thick soil pat into the liquid limits cup and using a grooving tool to divide the soil pat in half. The cup is then tapped on the base of the liquid limits device using a crank handle. The number of drops of the cup to close the gap formed by the grooving tool ½ inch is recorded along with the corresponding moisture content of the sample. This procedure is repeated several times at different moisture contents and a graph of moisture content and the corresponding number of blows is plotted. The liquid limit is the moisture content at a nominal 25 drops of the cup. From this test, the plasticity index can be determined by subtracting the plastic limit from the liquid limit.